Ballantine

INSTRUCTION MANUAL

MODEL 3501A
VAW
MULTIMETER

Applicable to Units with Serial Number Prefix 020

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90-10324-5A

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WARRANTY

This Ballantine Laboratories, Inc. product is warranted against defects in materials and workmanship for a period of one year from the date of shipment, except for batteries, electron tubes, vacuum thermal elements, and certain other components, if any, listed in this manual. Ballantine Laboratories, Inc. will, at its option, repair or replace products which prove to be defective during the warranty period provided they are returned to Ballantine Laboratories, Inc. prepaid, and provided the proper preventive maintenance and calibration procedures as listed in this manual have been followed. Repairs necessitated by misuse of the product are not covered by this warranty. NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. BALLANTINE LABORATORIES, INC. IS NOT LIABLE FOR CONSEQUENTIAL DAMAGES.

CERTIFICATION

Ballantine Laboratories, Inc. certifies that this equipment meets all applicable Ballantine specifications at time of shipment from the factory as determined by thorough testing and inspection. Ballantine further certifies that its measurements are traceable to the United States National Bureau of Standards. All instruments used in calibrating Ballantine products are standardized by systematic reference to NBS-traceable standards as described in the validation procedures shown below.

REFERENCE STANDARDS

DC	10mV-750V	0.002-0.003%
20Hz-50kHz	0.5V-500V	0.004%
20Hz-10MHz	0.5V-100V	0.05%
DC-30MHz	0.5V-100V	0.35%
DC-700MHz	10uV-0.5V	1%-NBS
10MHz-1000MHz	1V-300V	1%-NBS

WORKING STANDARDS

THERMAL VOLTAGE CONVERTERS, BALLANTINE 1397A
TRANSFER STANDARD, BALLANTINE 1605A
MICROPOTENTIOMETERS, BALLANTINE 440
RATIO TRANSFORMERS, GERTSCH

Ballantine's Quality Assurance program satisfied the requirements of MIL-I-45208

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Figure 1-1. Model 3501A

SECTION 1

GENERAL INFORMATION

1-1. INTRODUCTION

1-2. This manual provides operation and maintenance information for the Ballantine Model 3501A VAW Multimeter. Section 1 is a general description of Ballantine Model 3501A. Section 2 and 3 contain installation and operation instructions. The theory of operation is described in Section 4. Section 5 outlines maintenance and troubleshooting procedures. Section 6 has tables of replaceable parts and recommended spare parts. Section 7 contains schematic and assembly drawings. Section 8 describes the options and accessories which are available with Model 3501A.

1-3. Description

1-4. The Ballantine 3501A is a 4 1/2 digit, four function instrument which measures RMS ac and dc voltages, RMS ac and dc currents, relative voltage (in dB), and the average instantaneous power.

The instrument features a bright orange 11 mm (.43") LED display of 4 1/2 digits, permitting 19999 counts. Resolution is 10 uV, 10 nA ac and dc, as well as 10 nW and 0.01 dB. A rear panel dB reference adjustment control permits relative dB measurements. For voltage measurements, ranges are selected automatically. For current measurements, ranges are selected manually. In power measurement, voltage is selected automatically and current manually. Two off limit indicators, V and mA, are active in power measurements for simplified voltage and current off limit alarm. The decimal point and range annunciators are automatically displayed as the range is selected.

1-5. The 3501A is well protected against overloads. 750V on any voltage range or 2A on any current range will not damage the instrument. Recovery from overload is fast, enabling measurements to continue with no time loss. Protection is provided by means of electronic limiters except for the current ranges where the input is fuse protected. The fuse is accessible from the rear panel.

1-6. The 3501A features a display test. Simultaneously pushing mA and TEST will light all segments on the display for a quick check.

1-7. The 3501A may be used as a portable or bench instrument. GPIB (IEEE-488) Option 60 will adapt the 3501A to any existing automated system or data logging system.

1-8. The instrument is housed in a rugged and attractive metal case, and is small and light enough for easy portability. Quality components and reliable design techniques are used throughout to assure high reliability and low power consumption. A single circuit board is used for reliability and simplified maintenance.

1-9. INSTRUMENT and MANUAL IDENTIFICATION

1-10. The serial number of the instrument is located on the rear panel. The three left-most digits identify instrument modifications. If this prefix differs from that listed on the title page of this manual, there are differences between this manual and your instrument.

Technical corrections to the manual are listed on enclosed MANUAL ADDENDUM sheets (if any).

1-11. SPECIFICATIONS

1-12. Specifications are listed in Table 1-1. These specifications are the performance standards and/or limits to which the instrument can be tested. Model 3501A will comply with all specifications after at least 30 minutes warm up period.

1-13. ACCESSORIES

1-14. The accessories available are listed in Table 1-2.

1-15. OPTIONS

1-16. Several options are available. These options are listed in Table 1-3. Desired options may be specified at time of purchase. Contact your Ballantine representative for additional information. Refer to Section 8 for specifications and operating information.

TABLE 1-1. MODEL 3501A SPECIFICATIONS

Voltage:	
Ranges:	200 mV, 2V, 20V, 200V, 750V
Resolution:	10 μV on the 200 mV range
Max input:	750V rms (sinusoidal)
Ranging:	Automatic
Response:	True RMS
Crest Factor:	3:1 at full scale and increasing down scale (7:1 max)
Input Impedance:	10MΩ all ranges in parallel with <100 pF
Input Type:	Floating, 1000V max common to case
Input Coupling:	AC coupled or AC+DC
Accuracy (1 year, 20-30°C, above 10% of full scale)	DC - ±(.2% of input + .1% of range) 30 Hz - 45 Hz ±(.5% of input + .1% of range) 45 Hz - 10 kHz ±(.3% of input + .1% of range) 10 kHz - 20 kHz ±(1% of input + .2% of range) *20 kHz - 50 kHz ±(5% of input + .5% of range) *Sinewave only
Temperature Coefficient (0-20°C and 30-50°C)	±(.01% of reading + .005% of range)/°C
Response Time:	2 seconds max to rated accuracy. Add 1 second for each range change if autoranging is selected.
dB Mode	
Range:	From -40 dB to + 20 dB
Polarity:	Automatic + or - indicator
dB Reference:	Variable, may be adjusted by rear panel control to desired reference, or preset to 0 dBm (1mW into 600Ω)
dB Accuracy (1 year, 15-35°C)	DC - ±.3 dB
+20 to -30 dB	30 Hz - 45 Hz ±.4 dB 45 Hz - 10 kHz ±.5 dB 10 kHz - 20 kHz ±.6 dB 20 kHz - 50 kHz ± 1 dB
-30 to -40 dB	30 Hz - 10 kHz ±.6 dB

TABLE 1-1. MODEL 3501A SPECIFICATIONS - Cont'd.

Current

Ranges:	200 μA, 2 mA, 20 mA, 2000 mA, 10A
Resolution:	10 nA on the 200 μA range
Max Input:	2A from less than 250V. 20A max on the 10A range for 20 sec.
Ranging:	Manual
Response:	True RMS
Crest Factor:	3:1 at Full Scale and increasing down scale
Input Type:	Floating, 1000V max common to case
Input Coupling:	AC coupled or AC+DC coupling
Accuracy (1 year 20-30°C, above 10% of full scale)	DC ±(.2% of input + .1% of range) 30 Hz - 45 Hz ±(.5% of input + .1% of range) 45 Hz - 20 kHz ±(.3% of input + .1% of range) *20 kHz - 50 kHz ±(1% of input + .2% of range) *Sinewave only
Temperature Coefficient (0-20°C and 30-50°C)	±(.01% of reading + .005% of range)/°C
Response Time	2 seconds max to rated accuracy

Shunt resistance:

Range	10A	2000 mA	200 mA	20 mA	2 mA	200 μA
Resistance	0.01Ω	0.1Ω	1Ω	10Ω	100Ω	1000Ω
Compliance Volts	500 mV	300 mV	275 mV	250 mV	250 mV	250 mV

Wattage

Resolution:	10 nW on the 200 μA range
Max Input:	7.5 kW using the 10A range
Power Measured:	VI cos ϕ
Ranging:	Semi-Automatic. Select the appropriate current range manually and the Voltage range will be automatically selected. An error indicator lamp will light to help eliminate operator error in current range selection.
Dimensions:	Automatically displayed μW, mW, or kW
Accuracy (1 year, 20-30°C)	DC (VA) ±(.3% of input + .1% of range) 30 Hz - 45 Hz ±(1% of input + .2% of range) 45 Hz - 10 kHz ±(.5% of input + .1% of range) 10 kHz - 20 kHz ±(2% of input + .2% of range) 20 kHz - 50 kHz ±(5% of input + .5% of range)

TABLE 1-1. MODEL 3501A SPECIFICATIONS - Cont'd.

Angular Error between A and V inputs (typical error)	30 Hz - 1 kHz	1.5°
	1 kHz - 10 kHz	2.5°
	10 kHz - 20 kHz	3.5°
	*20 kHz - 30 kHz	5°
	*30 kHz - 50 kHz	8°
	*Sinewave only	

General

Display:	Seven segment LED .43" high. Automatic decimal point, polarity and dimensions indication
Reading Rate:	3 per second
Overrange Indication:	Flashing display
Max Common Mode Voltage:	1000 (DC+peak AC) common to case ground
Operating Temperature:	0-50°C
Humidity:	0-95% RH 40°C
Power Requirements:	115/230 V AC ± 10%, 48 to 400 Hz, 2 watt approx.
Dimensions:	80 mm x 250 mm x 295 mm (H x W x D)
Weight:	Approx. 3 kg
Supplied Accessories:	AC mains cable, two test leads with 4 inch probes and banana plug termination, and an instruction manual.

TABLE 1-2. ACCESSORIES

Model	Description
10800B/C	40 kV, HV DC Probe
1301B	10 kV, HV AC Probe
10850B	RF Probe, 100 kHz to 700 MHz
10851A	HV RF Probe Kit to 500 V and 1 GHz
10860A	Current Probe, AC, Clamp on to 1000 A
10861A	Current Probe, AC, Clamp on to 150 A
10801B	Test Lead Kit, 4 probes
12617A	Adapter, double banana to BNC female
12249D	Cable, BNC to BNC Shielded cable, 4 feet
12250D	Cable, BNC to alligator clips, 4 feet
12252D	Cable, Shielded, double banana to test probe

TABLE 1-3. AVAILABLE OPTIONS

Option	Description	Factory Installed	Field Installable
60	IEEE-488 Interface	Yes	No

SECTION 2

INSTALLATION

2-1. INTRODUCTION

2-2. This section outlines inspection and initial installation procedure. Details are provided for power connection, grounding, safety requirements, and packing instructions for storage or shipment.

2-3. UNPACKING and RECEIVING INSPECTION

2-4. Examine the shipping carton for damage before unpacking the instrument. Carefully remove the instrument from the carton. Check immediately for loose or broken control knobs, bent or broken connectors, and damage to any cabinet part. If damage of any nature is found, refer to the warranty instructions.

2-5. POWER REQUIREMENTS

2-6. The Model 3501A is designed to operate either from a 115V ac or 230V ac power source. The primary voltage selection is made by positioning a recessed slide switch on the rear panel. To change the position of the slide switch, insert a small screwdriver in the switch slot and set the switch to the required voltage position. Damage caused by using incorrect primary input voltage voids the instrument warranty.

2-7. The instrument should be operated from an ac power source with its neutral at or near ground (earth) potential. The instrument is not intended for operation from two phases of a multiphase ac system across the legs of a single-phase, three wire ac power system. Crest factor (ratio of peak voltage to rms) should be typically within the range of 1.3 to 1.6 at ± 10% of the nominal rms line voltage. Use a true rms responding voltmeter, such as the Ballantine Model 3620A, to measure the power line voltage.

WARNING

The instrument is provided with a three-connector power cord which will ground the case when connected to a three-connector grounding outlet. If a grounding outlet is not available, an adapter must be used which provides a good grounding connection.

2-8. GROUNDING REQUIREMENTS

2-9. To insure the safety of operating personnel, the U.S. Occupational Safety and Health Act (OSHA) and good engineering practice require that the instrument panel and enclosure be "earth grounded". All Ballantine instruments are provided with a three-conductor power cable assembly which, when plugged into an appropriate power receptacle, grounds the instrument. The offset pin on the male end of the power cable is the ground wire connection to the connector on the rear panel of the instrument.

2-10. To preserve the safety protection feature, when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green lead or terminal on the adapter to "earth ground".

WARNING

When using the instrument on external dc power or battery operation, use caution to avoid electrical shock and connect the instrument case to earth ground through the rear-panel grounding lug on the 3501A or the case ground binding post on the front panel of the 3501A.

2-11. PERFORMANCE CHECK

2-12. This instrument was carefully inspected for mechanical and electrical performance before shipment from the factory. This unit should be free of physical defects and should comply with all electrical specifications upon receipt. Check the instrument for possible damage incurred in transit and refer to the performance check outlined in paragraphs 5-13 through 5-21. If there is any indication of damage or improper operation, refer to the warranty included in this manual.

NOTE

Before using the instrument, exercise each of the pushbutton switches six or more times. This wiping action cleans switch contacts which may become noisy or intermittent during periods of storage or in contaminating environments.

2-13. ENVIRONMENTAL REQUIREMENTS

2-14. In order for the instrument to meet the specifications listed in Table 1-1, the operating temperature should be within the range of 0°C to +50°C.

WARNING

To prevent potential electrical hazard, do not expose instrument to rain or moisture.

2-15. MOUNTING

2-16. The instrument case is provided with a carry handle which also serves as a tilt stand. To change the position of the handle, unlock the nuts on both sides of the handle to disengage the detent mechanism. Rotate the handle to the desired position and lock the nuts until the handle detents into place. Outline dimensions are shown in Figure 2-1.

2-17. REPACKING FOR SHIPMENT OR STORAGE

2-18. The Model 3501A is a rugged instrument built to perform in severe environments. If the unit is to be shipped or stored for long periods of time, the following packing procedure is recommended:

a. Rotate the carry handle until it faces forward and protects the front panel. Coil the power cord and place the coil between the front panel and the handle. It may be desirable to tie the cord and/or put it into a snug fitting plastic bag.

b. Place the instrument into an oversize plastic bag and seal the bag.

c. For long distance shipping only, use U.S. Government packaging method IIC and tape a two unit bag of dessicant (MIL-D-3464) on the rear of the enclosure.

d. Place a piece of sturdy cardboard over the front panel for protection. Enclose the instrument in a plastic bag and seal the bag.

e. Wrap the bagged instrument and accessories in 1-inch thick, flexible, cellular plastic-film cushioning material (PP-B-795) and place in a barrier bag (MIL-B-131). Extract the air from the bag and heat seal.

f. Place the wrapped instrument and accessories into a fiberboard box (PPP-B-636) of suitable size. Fill spaces with rubberized hair or cellular plastic cushioning material. Close box in accordance with container specifications. Seal with sturdy water-resistant tape or with metal straps.

g. Mark container "FRAGILE", "HANDLE WITH CARE", or similar precautionary notice. Affix shipping labels as required or mark according to MIL-STD-129.

NOTE

If the instrument is to be shipped to Ballantine for calibration or repair, attach a tag to the instrument identifying the owner. Note the problem, the symptoms, and service or repair desired. Record the model and serial number of the instrument. Show the work authorization order as well as the date and method of shipment. Always obtain a RETURN AUTHORIZATION from the factory before shipping the instrument.

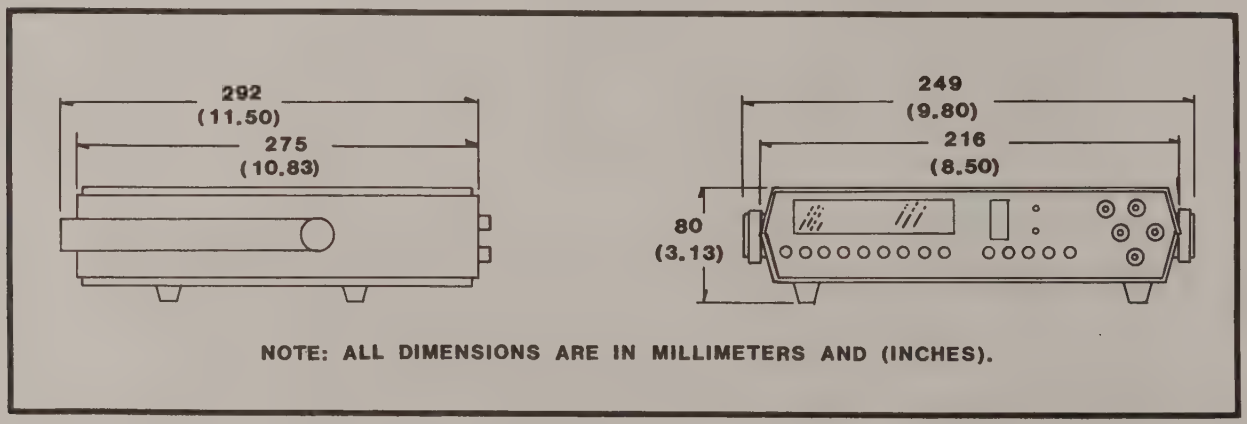


Figure 2-1. Model 3501A Outline Dimensions

TABLE 2-1. SAFETY CONSIDERATIONS

SAFETY CONSIDERATIONS

GENERAL

This is a Safety Class I instrument. This instrument has been designed considering IEC Publication 348 and ANSCI C39.5, "Safety Requirements for Electronic Measuring Apparatus".

This manual contains information, cautions, and warnings which must be followed by the service person to ensure safe operation and to retain the instrument in safe condition.

WARNINGS

SAFETY

If this instrument is to be energized via an autotransformer for voltage reduction, make sure the common terminal is connected to the earthed pole of the power source.

BEFORE SWITCHING ON THIS INSTRUMENT, the protective earth terminals of this instrument must be connected to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding).

Make sure that only fuses with the required rated current and of the specified type (normal blow, time delay, etc.) are used for replacement. The use of repaired fuses and the short-circuiting of fuse holders must be avoided.

Whenever it is likely that the protection offered by fuses has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

GROUNDING

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal is likely to make this instrument dangerous. Intentional interruption is prohibited.

HIGH VOLTAGE

Warning — These servicing instructions are for use by qualified personnel only. To avoid dangerous electric shock, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so.

CAUTIONS

LINE VOLTAGE SELECTION

BEFORE SWITCHING ON THIS INSTRUMENT, make sure the instrument is set to the voltage of the power source. Verify that the power transformer primary is matched to the available line voltage. Verify that the correct fuse is installed.

GROUNDING

BEFORE SWITCHING ON THIS INSTRUMENT, ensure that all devices connected to this instrument are connected to the protective (earth) ground. (Grounding one conductor of a two-conductor outlet is not sufficient.)

ATTENTION

This symbol: , which appears on the instrument means: Read the instruction manual before operating the instrument. If the instrument is operated without reading the instructions, it may not operate correctly.

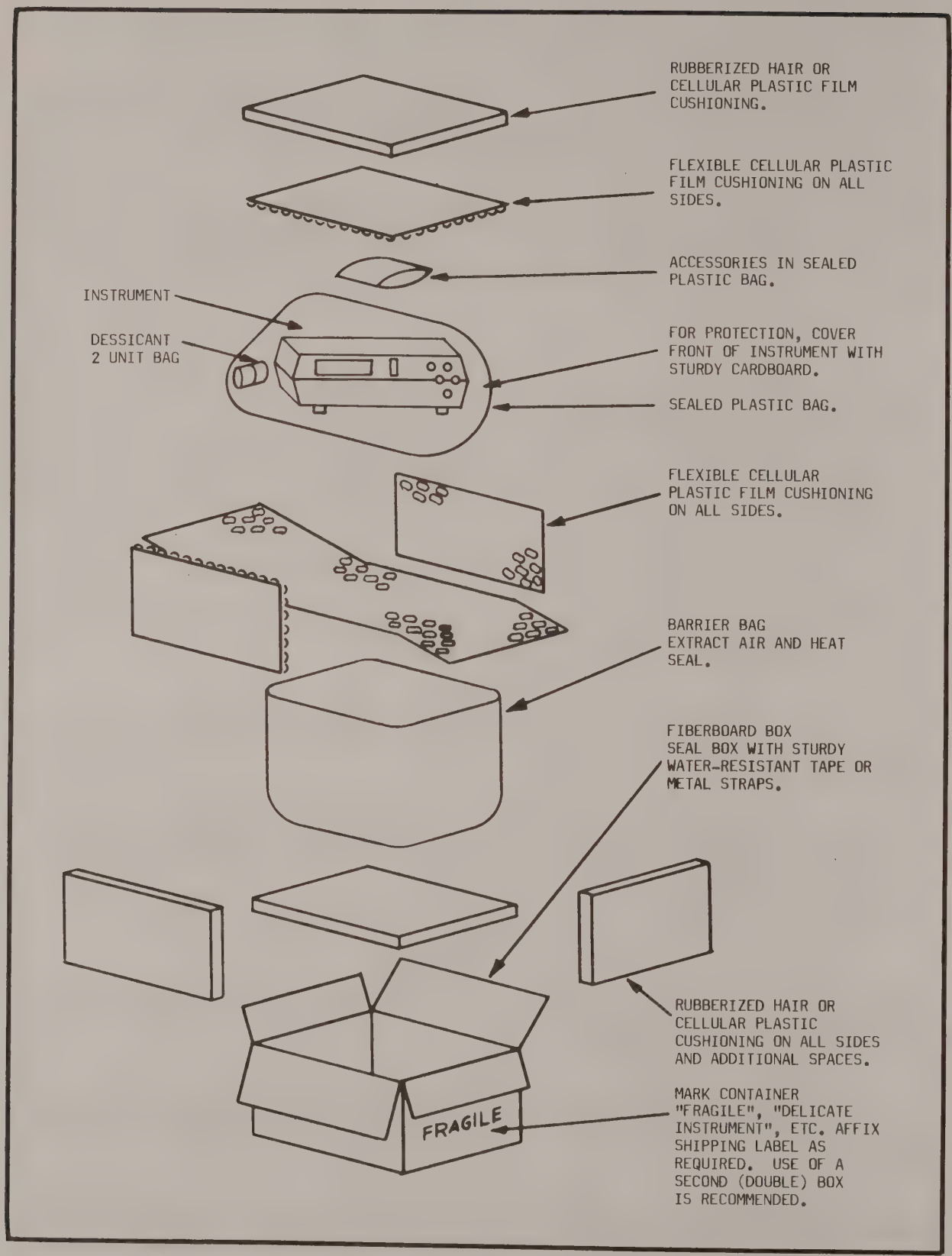

RUBBERIZED HAIR OR CELLULAR PLASTIC FILM CUSHIONING.
FLEXIBLE CELLULAR PLASTIC FILM CUSHIONING ON ALL SIDES.
ACCESSORIES IN SEALED PLASTIC BAG.
INSTRUMENT
DESSICANT 2 UNIT BAG
FOR PROTECTION, COVER FRONT OF INSTRUMENT WITH STURDY CARDBOARD.
SEALED PLASTIC BAG.
FLEXIBLE CELLULAR PLASTIC FILM CUSHIONING ON ALL SIDES.
BARRIER BAG EXTRACT AIR AND HEAT SEAL.
FIBERBOARD BOX SEAL BOX WITH STURDY WATER-RESISTANT TAPE OR METAL STRAPS.
RUBBERIZED HAIR OR CELLULAR PLASTIC CUSHIONING ON ALL SIDES AND ADDITIONAL SPACES.
FRAGILE
MARK CONTAINER "FRAGILE", "DELICATE INSTRUMENT", ETC. AFFIX SHIPPING LABEL AS REQUIRED. USE OF A SECOND (DOUBLE) BOX IS RECOMMENDED.

Figure 2-2. Packing Diagram

TABLE 2-2

SAFETY SYMBOLS

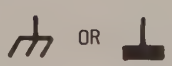
General Definitions of Safety Symbols Used On Equipment or In Manuals

Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.

Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).

Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating instrument.

Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.



Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

Alternating current (power line).

Direct current (power line).

Alternating or direct current (power line).

WARNING

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

NOTE

The NOTE sign denotes important information. It calls attention to procedure, practice, condition or the like, which is essential to highlight.

SECTION 3

OPERATION

3-1. INTRODUCTION

3-2. This section will familiarize the operator with the typical operating procedures for the instrument. The front and rear panel controls, connectors, and indicators are described.

3-3. CONTROLS, CONNECTORS, and INDICATORS

3-4. Figure 3-1 shows the instrument's front panel and Figure 3-2 shows the instrument's rear panel. Table 3-1 describes the functions. These descriptions are not intended to be operating instructions but, briefly, to familiarize the operator with the instrument. Table 3-2 describes the maximum allowable input conditions.

3-5. OPERATING INSTRUCTIONS

3-6. Paragraphs 3-7 through 3-10 outline instructions for making measurements with the Model 3501A. Each paragraph discusses a particular mode of operation.

3-7. VOLTAGE MEASUREMENT

a. Set POWER switch to ON

b. Set FUNCTION switch to V

c. Select a COUPLE mode (AC or DC)

d. Connect the voltage signal to be measured between V and COMMON binding posts. The binding posts accept wires, spade lugs, or banana plugs for ease of connecting the circuit to be measured.

e. Observe the displayed digits. Reading is directly in volts with the decimal point correctly positioned.

NOTE

In Voltage and Current measurements there is no polarity indication.

Range in Voltage measurement is selected automatically.

CAUTION

The measuring circuit is floated from the enclosure ground of the instrument. The maximum potential applied between COMMON and ground must not exceed 1000V dc or peak ac, or damage to the instrument may result.

f. For ac voltage measurements to 10 kV, use the optional Model 1301B AC Divider Probe.

g. For dc voltage measurements to 30 kV, use the optional Model 10800B/C HV DC Divider Probe.

3-8. CURRENT MEASUREMENT

a. Set POWER switch to ON.

b. Set FUNCTION switch to mA.

c. Select COUPLE mode AC or DC.

d. Select the desired current Range manually.

e. Connect the circuit to be measured between mA and COMMON binding posts.

f. Observe the displayed digits. Reading is directly in mA. Decimal point is correctly positioned.

g. For current measurement above 2A, use the 10A input terminal. The displayed reading then is directly in A.

NOTE

A flashing display indicates overload. Switch the current range switch to the next higher range until a steady display appears.

Unit may be used up to 30% overrange on all mA ranges but must not exceed 2A. For example, 250 mA would be displayed as 50.00 on the 200 mA range with a flashing display.

h. For current measurements to 150A, use the optional Model 10861A AC Current Clamp Probe. Divide displayed reading by 1000 when using the 10861 probe.

i. For current measurements to 1000A, use the optional Model 10860A AC Current Clamp Probe. Divide the displayed reading by 1000 when using the 10860 probe.

CAUTION

A current in excess of 2A, applied across the mA and COMMON terminals will blow the current range protection fuse. The operators should set up all the current measurements with this in mind and use the 10A terminal or ac current clamps when larger currents are to be measured.

3-9. dB MEASUREMENT

a. Set POWER switch to ON.

b. Set FUNCTION switch to dB.

c. Select a COUPLE mode AC or DC.

d. Set RANGE switch to +20 dB range.

e. Set Rear Panel 0 dBm reference to preset position (1mw/600Ω).

f. Connect the signal to be measured between V and COMMON binding posts.

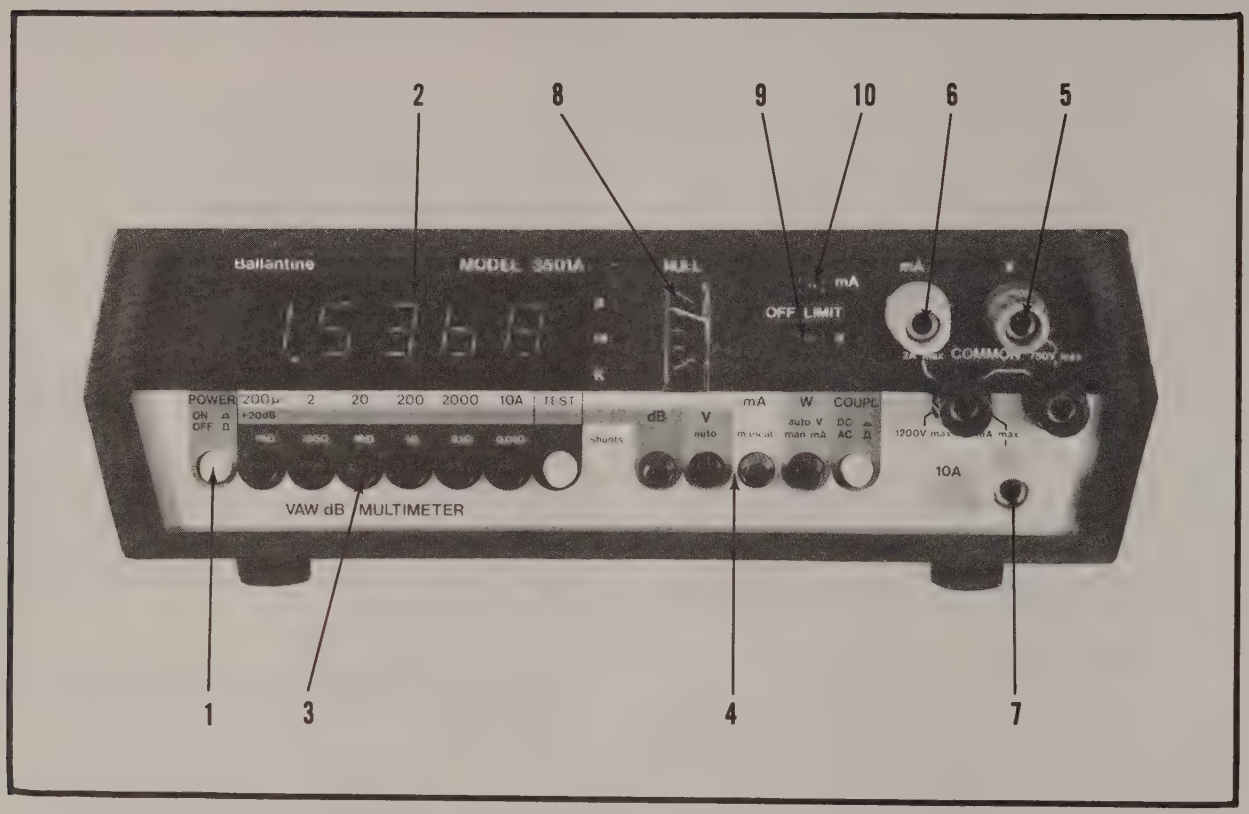


Figure 3-1. Front Panel Controls, Indicators, and Connectors

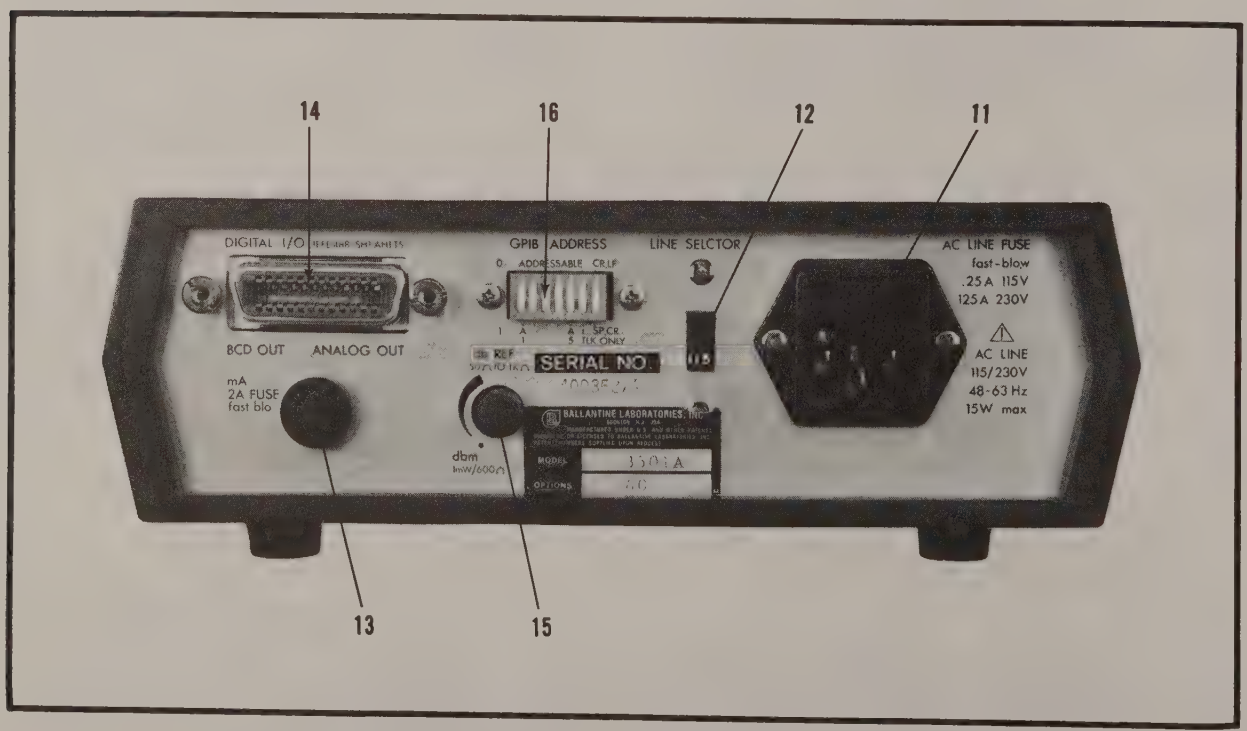


Figure 3-2. Rear Panel Controls, Indicators, and Connectors

TABLE 3-1. CONTROLS, INDICATORS, AND CONNECTORS

INDEX NO.	CONTROL, INDICATOR, OR CONNECTOR	DESCRIPTION
1	Power Switch	Switches instrument power ON or OFF. Power is on when switch is depressed.
2	Display	Digital readout consisting of four seven-segment LEDs and 1 plus a polarity indicator and three LED range indicators (μ, m, and k).
3	Range Switch	Selects one of six current ranges. Voltage range is selected automatically. There is one dB range of +20 dB full scale.
4	Function Switch	Selects one of four measurement functions: V, mA, W, and dB. Each function may be either ac or dc coupled.
5	V Input Terminal	Used in conjunction with the common terminal (8) for measuring ac and dc voltages relative dB and power.
6	mA Input Terminal	Used in conjunction with the common terminal (8) for measuring ac or dc current to 2A max.
7	10A Terminal	Used in conjunction with the common terminal (8) for measuring ac or dc current from 2A to 10A.
8	Null Meter	Used for dip or peak indication of the input signal. V and mA full scale is equivalent to 20,000 counts, W full scale is 5000 counts. Meter is not active in dB.
9	V Off Limit Indicator	Used in conjunction with Wattage measurement to indicate overranging in the voltage range. When lit, depress the V pushbutton and allow reading to stabilize.
10	mA Off Limit Indicator	Used in conjunction with Wattage measurement to indicate overrange in the current range. When lit, select a higher current range.
11	AC Power Receptacle and Mains Fuse	Connects ac mains power to instrument. Fuse protects ac mains circuits against accidental overload and the instrument against fire.
12	AC Mains Selector Switch	Selects voltage for 115V ac or 230V ac mains operation.
13	Fuse	Used for current range input overload protection.
14	Digital I/O	Used for connection to GPIB bus when Option 60 is installed.
15	dB Reference Adjust	Used for adjustment of 0 dB level. Preset position at 1 mW/600 Ω .
16	Address Switch	Used to select instrument IEEE-488 address when Option 60 is installed.

g. Observe the displayed digits. Reading is directly in dBm with 1mW/600Ω . Decimal point is correctly adjusted and polarity is correctly displayed.

h. For gain and loss measurements for other than 600Ω load (50Ω to 1.2kΩ) proceed as follows:

1. Set up Model 3501A as described above - paragraph 3-9, a to d.

2. Note your load impedance (R).

3. Apply this value to the formula V = 1mW x R and use the formula to find the voltage (V).

4. Apply the voltage (V) from a calibrator to the input terminals between V and COMMON.

5. Adjust the rear panel 0 dB REF control for a display reading of 00.00 dB.

6. Every measurement thereafter will be taken relative to the selected 0 dBm reference value.

EXAMPLES

1. Load impedance = 75Ω

V at 0 dB = $1 \times 10^{-3} \times 75 = 0.2739V$

2. Load impedance = 1 kΩ

V at 0 dB = $1 \times 10^{-3} \times 1 \times 10^{3} = 1.000V$

3-10. WATTAGE MEASUREMENT

a. Set POWER switch to ON.

b. Set FUNCTION switch to W.

c. Select a COUPLE mode AC or DC.

d. Set RANGE switch to 200 mA, or if the input current is known, select the known current range.

e. Connect the signal to be measured as described in Figure 3-3.

f. Observe the displayed digits. Reading is directly in Watts. Decimal point is correctly positioned. If V OFF LIMIT indicator is on, depress V button until a steady reading appears and then reselect the W mode. If mA OFF LIMIT indicator is on, select the next higher range until the indicator turns off.

NOTE

For Wattage measurement, the voltage range is selected automatically. mA and V OFF LIMIT indicators are used to help determine the appropriate current and voltage ranges. When either mA or V OFF LIMIT indicators are on, the displayed data is not valid.

When making power measurements always observe that your load series resistance is at least 100 times greater than the current shunt resistance as specified in Table 1-1 and marked on the front panel of your instrument.

CAUTION

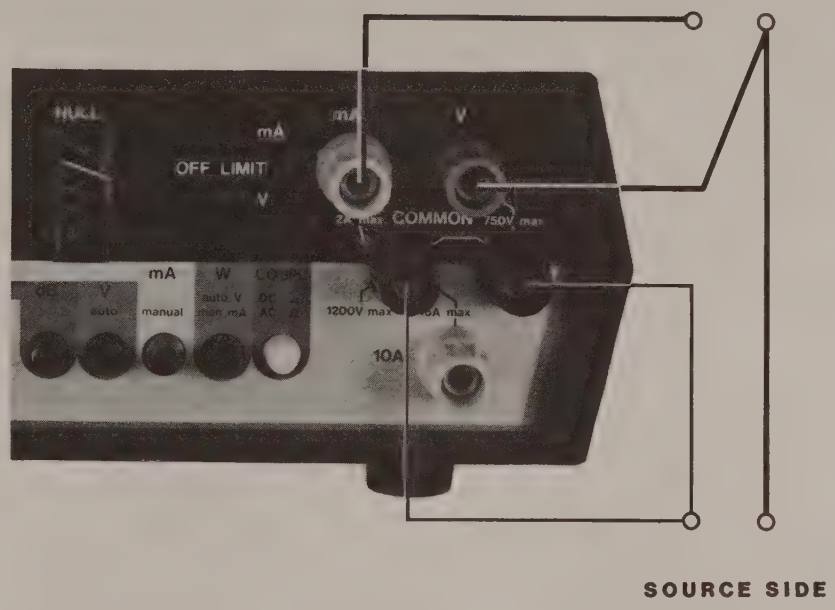
Before any attempt to measure power make sure that the applied voltage and current signals do not exceed the maximum limits as described in Table 3-2.

g. Wattage readings may be extended by using ac and dc voltage divider probes and ac clamp-on probes as described in paragraph 3-9 and 3-10.

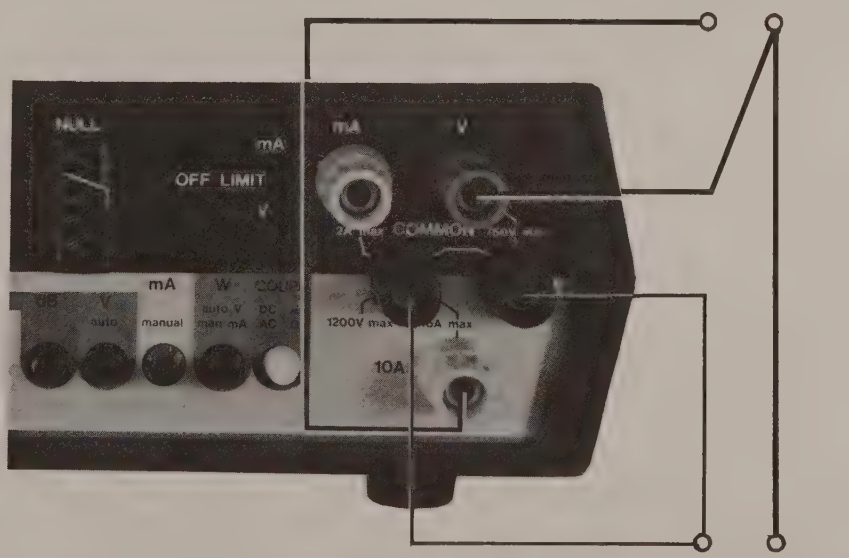
TABLE 3-2. MODEL 3501A MAXIMUM ALLOWABLE INPUT OVERLOAD CONDITIONS

Selected Function	Selected Range	Measurement Input Connection	Maximum Input Overload Limits
V	-	V and COMMON	750V dc or rms ac limited to 20 sec on 200 mV and 2V ranges.
mA	200A to 2000 mA	mA and COMMON	2A (Fuse Protected) Limited to 10 seconds.
mA	10A	10A and COMMON	20A (not protected).
dB	+20 dB	V and COMMON	250V rms
Any	Any	Case ground and COMMON	1000V peak

CURRENT UP TO 2A



CURRENT ABOVE 2A (10A MAX)



NOTES

1. A failure to connect the wires as described above will cause an error in the power measurement.
2. Use heavy gauge wires to avoid voltage drop due to lead resistance.

Figure 3-3. Correct Wire Connection for Wattage Measurement

3-11. MEASUREMENTS USING THE NULL METER

3-12. In any application where peaking or dipping of signal is required, it is convenient to use the null meter. A full scale of the null meter in V and mA measurements is equal to 20,000 counts on the digital display. In power measurement full scale of the null meter is equal to 5000 counts. Null meter is inoperative in the dB mode.

3-13. DISPLAY CHECK

a. Set POWER switch to ON and remove all input signal leads.

b. Depress mA and TEST pushbuttons.

c. Display reading should be 8888.

SECTION 4

THEORY OF OPERATION

4-1. INTRODUCTION

4-2. This section of the manual contains a description of the circuitry used in the 3501A. Figure 4-1 is a detailed block diagram for the 3501A. Basically the diagram can be broken down into 8 fuctional areas: dc voltmeter circuit, rms and dB converter, analog multiplier, autoranging control, voltage input attenuator, current shunts, and power supply.

A complete schematic diagram is given in Section 7. Refer to this diagram throughout the following description.

4-3. DC VOLTMETER CIRCUIT

4-4. The dc voltage is coupled to the analog processor through R42. C15 is a low pass filter. The monolithic analog processor contains a bipolar comparator, a bipolar integrating amplifier, two MOS-FET input amplifiers, several analog switches, and the necessary level shifting drivers to allow the analog and digital processors to be directly interfaced. The digital processor A2 U2 combines the counting, storage, and data multiplexing functions with the random logic necessary to control the function of the analog processor. Output buffers provide the sign, digit strobes, and multiplexed BCD data outputs. The digit scan is an interlace format of digits 5, 4, 3, 2, and 1.

4-5. A measurement cycle consists of two parts: the measure interval and the auto-zero interval.

a. In the measure interval a conversion technique balances the charge supplied by a current proportional to the input voltage with an accumulation of quantized charges equal to a BCD count. The units of quantized charge are provided through pulsewidth-modulation of a reference current.

b. The auto-zero interval allows the effect of offset, temperatures, and drift to be impressed on the auto-zero storage voltage, which is maintained as a reference by the capacitor C25. Therefore, during the succeeding measure interval, these effects will be balanced out. The input of the buffer amplifier is grounded during this interval.

4-6. The digital processor has a built in overrange flashing circuit. The presence of a count of 20000 or greater in the BCD counter causes the 4 1/2 digit display to blink off during the zero cycle resulting in a blink rate equal to the sampling rate.

4-7. The decoder driver A2-U3 translates the BCD information from the digital processor to drive the anodes of the LED readouts DS1, DS2, DS3, and DS4. The cathodes are controlled by the digital processor A1-U4. The digit strobe pulses from A2-U1 determine which readout receives the proper anode voltage at the proper time. The most significant digit is readout DS5. Two segments are used to form a numerical "1" and two other segments form the plus or minus polarity signs. The "1" segments are driven by transistor A2-Q1, while the polarity signs are driven by A2-U4. The decimal point illumination is controlled by A2-U2 and A2-Q2.

4-8. Timing signals for the analog and digital processors are generated by the free-running oscillator A2-Q3, L1, C2, C3, R11, and R12.

4-9. TRUE RMS AND dB CONVERTER

4-10. The true rms ac to dc converter consists of a wide-band true rms converter U4. Series capacitor C1 blocks dc voltages when ac coupled so that only ac voltages are being measured. In dc coupling mode C1 is shorted and the rms converter is capable of measuring ac signals riding on dc levels. U5 is an amplifier with gain calibrated to give a dc level proportional to the dB output of U4. R16 is a temperature sensitive resistor for compensation of the dB and rms accuracy with ambient temperature changes.

4-11. ANALOG MULTIPLIER

4-12. The analog multiplier consists of a wide band four quadrant multiplier U3; integrator R27, C23; a x10 gain amplifier U22; comparator U13; and associated components. AC signals into the multiplier input are multiplied instantaneously according to the equation:

$$Vout = \frac{[(X-X_1)\ (Y-Y_1)]}{10} + (Z-Z_1).$$

X_1, Y_1, and Z_1 are in circuit offset adjustments. The output of U3 is integrated and amplified to give a dc output proportional to the relationship:

$$V(DC) = XY \cos \phi$$

4-13. The comparator U13 controls the dynamic range of the analog multiplier and, with mA and V OFF LIMITS LEDs, signals when input signals exceed the dynamic range.

4-14. AUTORANGING CONTROL

4-15. The Autoranging Control comprises U14, the overrange and underrange detector; U15, the up down counter with binary output; U16, the binary to decimal encoder; U18, the ROM; and their associated components. The autoranging control is active in voltage measurement and in wattage measurement where voltage ranges are being selected automatically. U18 is programmed to give the correct indication of decimal points and dimensions. Relays K1, K2, K3, and K4 determine the attenuation and gain and are controlled by U16.

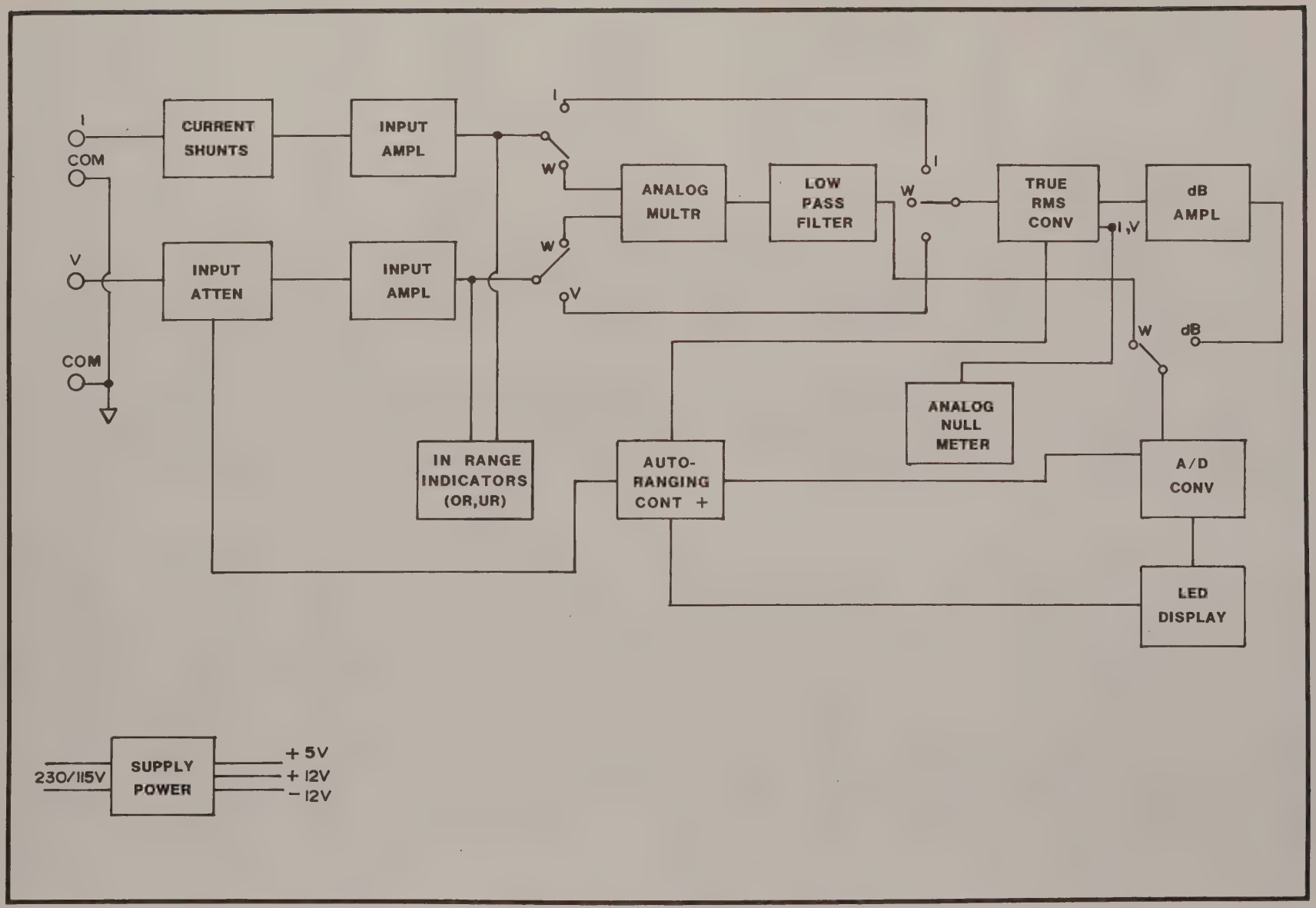


Figure 4-1. Model 3501A, Detailed Block Diagram

4-16. VOLTAGE INPUT ATTENUATOR

4-17. The Voltage Input Attenuator consists of RN1, a precision resistive divider with an excellent ratio accuracy and temperature stability. C2, C5, C6, C7, and C8 compensate the input divider in high frequency application.

4-18. Input voltage may be dc or ac coupled via C1 and S12D. The voltage from the input divider is coupled through R11 to U1, the input amplifier. U1 is a wide band, high input impedance amplifier. U1 is used in two modes: as a voltage follower when K2 is shorted, and as a x10 amplifier when K2 is open.

4-19. CURRENT SHUNTS

4-20. The current shunts comprise R1, R6, R7, R8, R9, and R10 precision resistors. The current through each resistor causes a voltage drop which is proportional to the input current. This voltage is amplified x10 by U2 and applied to the next stage. F2 is a protection fuse which limits the input current to 2A. CR4 is a voltage burden limiter.

4-21. POWER SUPPLY

4-22. The Power Supply circuit provides a regulated plus and minus 15.0 volt source for the analog and reference circuitry and a regulated +5 volt source for the timing, digital processor, display circuit, ranging circuit, and relays.

4-23. The full-wave bridge rectifier CR17 and capacitor C26 supply an unregulated dc voltage. This voltage is applied to the input of .5V voltage regulator U20.

4-24. The dc to dc converter consists of a solid state switch Q6 and differential amplifier Q1 and Q2. The pulses generated are rectified by CR14 and CR15. Capacitors C30 and C31 filter the rectified ± 15 volt supplies.

4/6/88

Please review procedure when next unit is here for calibration. Update procedure and have approved per P442 procedure guidelines.

MJ Moore

SECTION 5

MAINTENANCE AND CALIBRATION

5-1. INTRODUCTION

5-2. This section provides maintenance, service information, performance test, calibration, and troubleshooting procedures for the Model 3501A. Included is a table of recommended test equipment. Calibration should be performed every 12 months or whenever Performance Check (see paragraph 5-13) indicates that the Model 3501A is out of specifications. If any step in the calibration procedure cannot be performed properly, refer to troubleshooting information in this section, or contact your Ballantine representative.

NOTE

Calibration should be performed by qualified personnel using reliable and accurate test equipment.

5-3. TEST EQUIPMENT

5-4. Recommended test equipment for troubleshooting, calibration, and performance checking is listed in Table 5-1. Test instruments other than those listed may be used if their specifications equal or exceed the required characteristics.

5-5. INSTRUMENT COVER REMOVAL

5-6. To remove the top or bottom cover, remove the four screws on the sides of the cover. To replace the covers, reverse the procedure.

WARNING

115/230 Vac line voltages are exposed when top cover is removed. Disconnect the ac mains power cord and all input signal connections before removing the covers.

5-7. CLEANING

5-8. The Model 3501A should be cleaned as often as operating conditions require. Thoroughly clean both the inside and the outside of the instrument. Remove dust from inaccessible areas with low pressure compressed air or vacuum cleaner. Use alcohol applied with a cleaning brush to remove accumulations of dirt or grease from connector contacts and component terminals. Clean the exterior of the instrument and the front panel with a mild detergent mixed with water, applying the solution with a soft, lint-free cloth. Lubricate the switch contacts with suitable lubricant such as WD-40 spray.

5-9. FUSE REPLACEMENT

5-10. The ac mains power fuse is located on the rear panel. To replace the fuse, pry off the fuseholder cover with a screwdriver. The current range protection fuse is also located on the rear panel. Access to this fuse is provided by unscrewing the retaining cap of the fuse holder. When replacement is required, observe the recommended fuse rating to maintain protection for the instrument against current range damage and fire hazard.

5-11. REPAIR AND REPLACEMENT

5-12. Repair and replacement of electrical and mechanical parts must be accomplished with care and caution. Printed circuit component boards can become warped, cracked, or burnt from excessive heat or mechanical stress. The following repair techniques are suggested to avoid inadvertent destruction or degradation of parts and assemblies.

a. Use ordinary 60/40 solder and a 35 to 40 watt pencil type grounded soldering iron on the circuit board. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may seperate the circuit from the base material. Keep the soldering iron in contact with the PC board for a minimum time to avoid damage to the components or printed conductors.

b. To desolder components use a commercial "solder sipper", or better, solder-removing SOLDER-WICK, size 3.

TABLE 5-1. RECOMMENDED TEST EQUIPMENT

MODEL	SPECIFICATION
Fluke 341A	DC Calibrator 10 mV to 1000V ± 0.002%
HP 745A & 746A	AC Calibrator 10 mV to 1000V ± 0.02%
Ballantine 1620A	Transconductance Amplifier AC/DC Current Calibrator 200 µA to 20A; AC/DC: ± .25% AC; ± 0.02% DC
Krohn Hite 6200	Phase Meter -180° to +180° ± 0.1%
Ballantine 12-12861-0	Resistor 10k ohm 0.05% 7W

c. Always replace a component with its exact duplicate as specified in the parts list.

NOTE

This instrument uses static sensitive components. To avoid damage always use static protection precautions which include grounded work stations, grounded soldering iron, and apply a ground strap to the maintenance technician.

5-13. PERFORMANCE CHECK

5-14. The following performance check verifies proper operation of the instrument, and should normally be used:

a. as part of incoming inspection of instrument specifications;

b. as part of troubleshooting procedure;

c. after any repairs or adjustments, before returning instrument to regular service.

NOTE

Prior to any of the following performance checks, allow at least 30 minutes warm-up period. Internal circuitry must reach a thermal equilibrium otherwise incorrect readings may be obtained.

5-15. DC VOLTAGE ACCURACY CHECK

5-16. To check the accuracy of the Model 3501A for dc voltage measurements, proceed as follows:

a. Set POWER switch to ON.

b. Set FUNCTION switch to V.

c. Set COUPLE switch to DC.

d. Set output of DC Voltage Standard to zero.

e. Connect the V and COMMON input terminals from the 3501A to the (+) and (-) output terminals respectively on the voltage standard. Use sensing cables.

f. Check accuracy at each setting of voltage standard listed in Table 5-2. In each case the readout should be within the tolerance shown.

g. Reduce the DC Voltage Standard output to zero and disconnect the test instrument from the DC Voltage Standard.

TABLE 5-2. DC VOLTAGE ACCURACY CHECK

APPLIED VOLTAGE	READOUT LIMITS	
	MIN.	MAX.
00.00	00.00	00.20
± 100.00 mV	99.60	100.40
± 1.0000 V	.9960	1.0040
± 10.000 V	9.960	10.040
± 100.00 V	99.60	100.40
± 750.0 V	746.5	753.5

5-17. DC CURRENT ACCURACY CHECK

a. Set POWER switch to ON.

b. Set FUNCTION switch to mA.

c. Set COUPLE switch to DC.

d. Set output of dc current standard to zero.

e. Check accuracy at each setting of the dc current standard listed in Table 5-3. In each case the readout should be within the tolerance shown.

f. Disconnect the current source from the VAW multimeter under test.

5-18. dB ACCURACY CHECK

a. Set POWER switch to ON.

b. Set FUNCTION switch to dB.

c. Set RANGE switch to +20 dB.

d. Set COUPLE switch to DC.

TABLE 5-3. DC CURRENT ACCURACY CHECK

RANGE SWITCH SETTING	APPLIED CURRENT	READOUT LIMITS	
		MIN.	MAX.
200 µA	00.00 A	00.00	00.20
200 µA	± 100.00 µA	99.60	100.40
2 mA	± 1.0000 mA	.9960	1.0040
20 mA	± 10.000 mA	9.960	10.040
200 mA	± 100.00 mA	99.60	100.40
2000 mA	± 1000.0 mA	996.0	1004.0

ON REAR OF UNIT

e. Set dB Reference control on the rear panel maximum counterclockwise to 1mW/600Ω position. The control must detent in this position.

f. Connect the V and COMMON INPUT terminals from the 3501A to the DC Voltage Standard.

g. Check accuracy at each setting of the DC Voltage Standard listed in Table 5-4. In each case the readout should be within the tolerance shown.

h. Disconnect the voltage source from the VAW Multimeter under test.

5-19. AC VOLTAGE ACCURACY CHECK

a. Set POWER switch to ON.

b. Set FUNCTION switch to V.

c. Set COUPLE switch to AC.

d. Set output of AC Voltage Standard to zero.

e. Connect the V and COMMON terminals of the 3501A to the output terminals of the ac voltage source.

f. Check the accuracy of each setting of the AC Voltage Standard listed in Table 5-5. In each case the reading should be within the tolerance shown.

g. Reduce the voltage standard to zero and disconnect the voltage source from the VAW Multimeter.

5-20. AC CURRENT ACCURACY CHECK

a. Set POWER switch to ON.

b. Set FUNCTION switch to mA.

c. Set COUPLE switch to AC.

d. Set output of ac current standard to zero.

e. Connect the mA and COMMON terminals of the 3501A to the output terminals of the ac current source.

f. Check the accuracy at each setting of current standard listed in Table 5-6. In each case the readout should be within the tolerance shown.

5-21. DC WATTAGE ACCURACY CHECK

a. Set POWER switch to ON.

b. Set FUNCTION switch to W.

c. Set COUPLE switch to dc.

d. Set output of dc voltage and dc current standards to zero.

TABLE 5-4. dB ACCURACY CHECK

RANGE SWITCH SETTING	APPLIED VOLTAGE	READOUT LIMITS	
		MIN.	MAX.
+ 20 dB	+ 0.7746	- 00.30	+ 00.30
+ 20 dB	+ 7.746	+ 19.70	+ 20.30
+ 20 dB	+ 0.07746	- 19.70	- 20.30
+ 20 dB	+ 0.007746	- 39.40	- 40.60

TABLE 5-5. AC VOLTAGE ACCURACY CHECK

APPLIED VOLTAGE	READOUT LIMITS					
	50 Hz to 10 kHz		10 kHz to 20 kHz		20 kHz to 50 kHz	
	MIN.	MAX.	MIN.	MAX.	MIN.	MAX.
00.00 V	00.00	00.20	00.00	00.20	00.00	00.20
100.00 mV	99.50	100.50	98.60	101.40	94.00	106.00
1.0000 V	.9950	1.0050	.9860	1.0140	.9400	1.0600
10.000 V	9.950	10.050	9.860	10.140	9.400	10.600
100.00 V	99.50	100.50	98.60	101.40	94.00	106.00
750.00 V	745.7	754.3	738.5	761.5	702.5	797.5

TABLE 5-6. AC CURRENT ACCURACY CHECK

RANGE SWITCH SETTING	APPLIED CURRENT	READOUT LIMITS			
		50 Hz to 20 kHz		20 kHz to 50 kHz	
		MIN.	MAX.	MIN.	MAX.
200 µA	00.00	00.00	00.20	00.00	00.20
200 µA	100.00 µA	99.50	100.50	98.60	101.40
2 µA	1.0000 mA	.9950	1.0050	.9860	1.0140
20 mA	10.000 mA	9.950	10.050	9.860	10.140
200 mA	100.00 mA	99.50	100.50	98.60	101.40
2000 mA	1000.0 mA	995.0	1005.0	986.0	1014.0
10 A	10.000 A	9.950	10.050	9.860	10.140

TABLE 5-7. DC WATTAGE ACCURACY CHECK

RANGE SWITCH SETTING	APPLIED CURRENT	APPLIED VOLTAGE	READOUT LIMITS		DIMENSIONS
			MIN.	MAX.	
200 µA	100 µA	1 V	99.50	100.50	µ
2 mA	1 mA	1 V	.9950	1.0050	m
20 mA	10 mA	1 V	9.950	10.050	m
200 mA	100 mA	10 V	.9950	1.0050	-
2000 mA	1 A	10 V	9.950	10.050	-
10 A	2 A	100 V	197.0	203.0	-

e. Connect the V and COMMON terminals of the 3501A to the output terminals of the dc voltage source.

f. Connect the mA and COMMON terminals of the 3501A to the output terminals of the dc current source.

NOTE

Always observe that both COMMON terminals of the 3501A will be connected to the - or ground side of the voltage and current sources.

g. Check the accuracy at each setting listed in Table 5-7. In each case readout should be within the tolerance shown.

h. Reduce the voltage and current sources to zero and disconnect the leads from the 3501A.

5-22. AC WATTAGE ACCURACY CHECK

a. Set POWER switch to ON.

b. Set FUNCTION switch to W.

c. Set COUPLE switch to AC.

d. Connect a 10 kΩ 0.1% resistor rated to at least 2W between mA and V input terminals.

e. Set output of ac voltage standard to zero.

f. Connect the V and COMMON terminals of the 3501A to the output terminals of the ac voltage source.

g. Check the accuracy at each setting listed in Table 5-8. In each case readout should be within the tolerance shown.

h. Reduce the voltage source to zero and disconnect the leads from the 3501A.

5-23. ALIGNMENT AND CALIBRATION PROCEDURE

5-24. If any of the performance checks fail, a recalibration may be required. Table 5-1 lists the test equipment that is required to perform complete calibration of the instrument.

5-25. POWER SUPPLIES

5-26. The Model 3501A has no power supply adjustments, but voltage limits should be checked

* Resistor may need to be varied to obtain -

TABLE 5-8. AC WATTAGE ACCURACY CHECK

RANGE SWITCH SETTING	APPLIED VOLTAGE	APPLIED FREQUENCY	READOUT LIMITS	
			MIN.	MAX.
20 mA	100 V	30 Hz	.986	1.014
20 mA	100 V	100 Hz	.993	1.007
20 mA	100 V	20 kHz	.976	1.024
20 mA	100 V	50 kHz	.940	1.060

before recalibration. Test points are clearly marked on the upper side of the main PC assembly board.

TABLE 5-9. DC POWER SUPPLY CHECKS

SUPPLY	VOLTAGE LIMIT	RIPPLE
+ 15V	+ 14V to + 16V	50 mV p-p
- 15V	- 14V to - 16V	50 mV p-p
+ 5V	+ 4.75V to + 5.25	100 mV p-p

5-27. CALIBRATION PROCEDURE

5-28. All calibration procedures are performed with the POWER switch turned on. The top cover should be removed to allow access to test points and adjustments. Do not remove the bottom shield.

WARNING

Some procedures require the use of high voltage. Take special care to prevent contact with live circuits or power line area which could cause electrical shock resulting in serious injury or death. Use an insulated tool when making adjustments.

5-29. Refer to the component layout when necessary for determining adjustment points.

5-30. Before making any attempt to calibrate the instrument, make sure that all circuits are working properly according to the troubleshooting procedure.

5-31. Turn POWER to ON and allow about 1 hour to warm-up and to achieve zero stability. Cover the instrument during the warm-up period to control instrument temperature.

5-32. Refer to Table 5-10 and perform the listed adjustments in the sequence indicated. The sequence must be followed exactly in the given order because the adjustments are interrelated and dependent on the preceding steps. If an adjustment cannot be made to obtain the specified reading, refer to the troubleshooting information in this section.

5-33. TROUBLESHOOTING

5-34. The troubleshooting instructions contained in this section are intended for qualified personnel having a basic understanding of analog and digital electronic principles and components used in precision electronic test instruments. Instructions have been written to assist in isolating the defective circuit or subcircuit. Isolation of the specific defective component has been left to the technician.

NOTE

For instruments that are still under warranty, if the instrument's performance is outside of specifications at any point, contact your Ballantine representative or the factory before attempting troubleshooting or repair, other than fuse replacement.

5-35. TROUBLESHOOTING PROCEDURE

5-36. This section contains tables listing step by step checks of major VAW Digital Multimeter circuits. Bottom shields must be removed to gain access to test points and components for troubleshooting.

WARNING

The opening of covers or removal of parts, except those to which access can be gained by hand is likely to expose live parts. In addition, accessible terminals may also be live. The apparatus shall be disconnected from all voltage sources before any adjustment, part replacement, or maintenance and repair are performed. If any adjustment, maintenance, or repair of the opened apparatus is required, it shall be carried out only by a skilled person who is aware of the hazard involved.

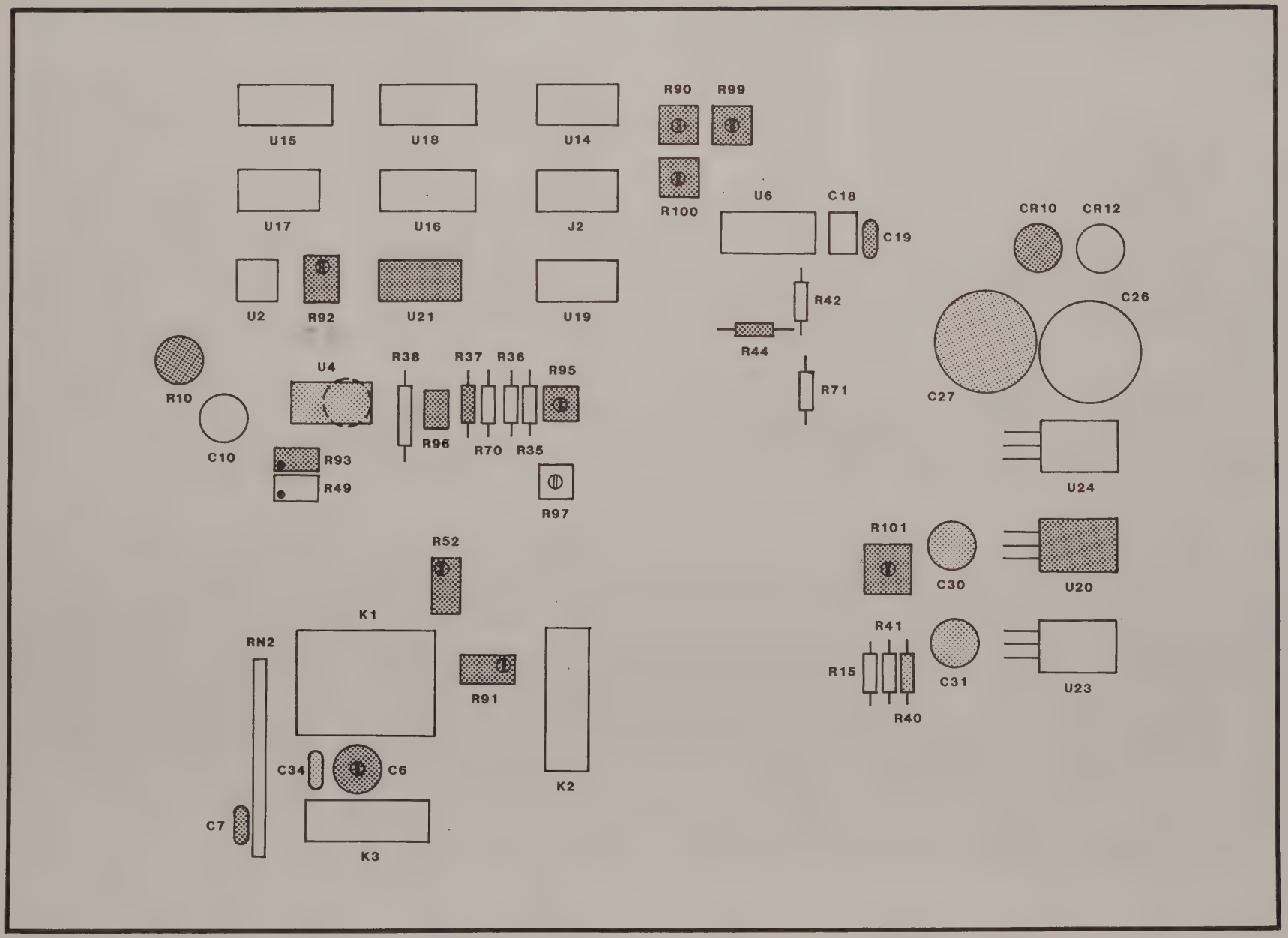


Figure 5-1. Main Board and Power Supply Adjustments and Test Points

TABLE 5-10. CALIBRATION PROCEDURE

STEP	FUNCTION	COUPLE	RANGE	PROCEDURE	ADJ.	REQUIRED READING*	TEST EQUIPMENT
1	V	AC	---	Short input COMMON to pin 15-U6 (LD120)	C19	.000 ± 1	None
2	V	AC	---	Apply 1.9V dc between U6 pin 15 and input COMMON	R100	1.9000 ± 1	DCV Calibrator
3	mA	AC	200	Short input COMMON to pin 1 of U4 (AD536)	R95	00.00 ± 2	None
4	mA	DC	200 μ	Short between mA and COMMON input terminals	R92	00.00 ± 2	None
5	V	DC	---	Short between V and COMMON input terminals	R91	00.00 ± 2	None
6	V	DC	---	Apply 1.9V dc between V and COMMON input terminals	R96	1.9000 ± 10	DCV Calibrator
7	V	DC	---	Short between V and COMMON input terminals	R95	.0000 ± 2	None
8	V	DC	---	Repeat steps 6 and 7			
9	V	AC	---	Apply 190V/10kHz between V and COMMON input terminals. If adjustment cannot be made, select C-34 (normally not required except when major components are replaced.	C6	190.00 ± 20	ACV Calibrator
10	V	AC	---	Apply 750V/10kHz between V and COMMON input terminals. If not within specified range, select C7 (normally not required except when major componenets are replaced).	C7	750.0 ± 20	ACV Calibrator
11	V	AC		Repeat steps 9 and 10.			
12	mA	DC	2000	Apply 1.9A dc between mA and COMMON input terminals. Adjust by soldering the top wire and moving it along the resistance wire.	R10	1.9000 ± 10	DCA Calibrator
13	mA	DC	10 A	Apply 10A dc between the 10A and COMMON input terminals. Adjust by unsoldering the top wire and moving it along the exposed resistance wire.	R1	10.000 ± 10	DCA Calibrator
14	dB	DC	+ 20 dB	Rotate rear panel potentiometer to maxinum counterclockwise position. Feel that it detents into the dBm position. Apply 0.775V dc between V and COMMON input terminals. If adjustment cannot be made, select R40 (normally not required except when major components are replaced.	R101	+ 00.00 ± 5	DCV Calibrator

* Tolerance in allowable digits.

TABLE 5-10. CALIBRATION PROCEDURE - Cont'd.

STEP	FUNCTION	COUPLE	RANGE	PROCEDURE	ADJ.	REQUIRED READING*	TEST EQUIPMENT
15	dB	DC	+ 20 dB	Apply 7.75V dc between V and COMMON input terminals.	R37	+ 20.00 ± 10	DCV Calibrator
16	dB	DC	+ 20 dB	Repeat steps 14 and 15			
17	V	DC	---	Null meter linearity adjustment. Apply 2V dc between V and COMMON input terminals.	R99	Full Scale Deflection	DCV Calibrator
18	V	DC	---	Apply 1V dc between V and COMMON input terminals.	R90	Mid-scale Deflection	DCV Calibrator
19	V	DC	---	Repeat steps 17 and 18 until meter linearity is achieved.			
20	W	AC	2000 m	Short between V and COMMON input terminals.	R93	000.0 ± 2	None
21	W	AC	2000 m	Apply + 190 mV dc between V and COMMON input terminals.	R44	000.0 ± 10	DCV Calibrator
22	W	DC	2000 m	Apply - 190 mV dc between V and COMMON input terminals.	R44	000.0 ± 10	DCV Calibrator
23	W	DC	2000 m	Repeat steps 21 and 22 until reading is the same on both adjustments.	R44	000.0 ± 10	DCV Calibrator
24	W	DC	2 m	Short between V and COMMON input terminals. Apply + 1 mA dc between mA and COMMON input terminals.	R52	000.0 ± 10	DCA Calibrator
25	W	DC	2 m	Short between V and COMMON input terminals. Apply - 1 mA dc between mA and COMMON input terminals.	R52	000.0 ± 10	DCA Calibrator
26	W	DC	2 m	Repeat steps 24 and 25 until reading is the same on both adjustments.	R52	000.0 ± 10	DCA Calibrator

Steps 20 thru 23: Select V function and wait for a steady display, then select W.

* Tolerance in allowable digits.

NOTE

Whenever a replacement of U3 is necessary, obtain a replacement from your nearest Ballantine sales facility or contact the Ballantine factory directly. An attempt to replace U3 without a factory supplied replacement may result in reduced accuracy over the specified temperature range.

5-37. INTERMITTENT SWITCHES

5-38. When the multimeter has been stored for a period of time or has been exposed to caustic fumes, acid fumes, oil fumes, hydrogen sulfide, or other contaminents, the pushbutton switches may become noisy or intermittent even though specially treated high quality contacts are used throughout. Push each button ten or more times to permit self-wiping action of switches to clean the contacts and eliminate the problem.

TABLE 5-11. POWER SUPPLY TROUBLESHOOTING

STEP	PROCEDURE	REQUIRED REACTION	CORRECTIVE PROCEDURE
1	Check for correct line voltage setting of the LINE SELECTOR switch located on the rear panel.		Use a screwdriver to slide rear panel LINE SELECT switch to the correct ac mains voltage setting.
2	Assure that ac mains power cord is properly plugged in.		
3	Measure power supply voltages at the solder links.	+ 15V ± 0.5V dc - 15V ± 0.5V dc + 5V ± 0.25V dc	If voltages are other than specified, use a soldering iron and solder sucker to disconnect the solder links. This isolation of the power supply from all circuits is provided for easy troubleshooting.
4	Measure dc voltage across filter capacitor - C26	+ 8 to + 11V dc	Check power transformer, replace ac mains fuse, check CR10.
5	Measure dc voltage across capacitor C-27.	+ 5V ± 0.25V dc	Replace U20.
6	Measure voltage across C30.	+ 15V ± 0.5V dc	Replace U20.
7	Measure voltage across C31.	- 15V ± 0.5V dc	Replace U21.
8	Resolder solder links.		

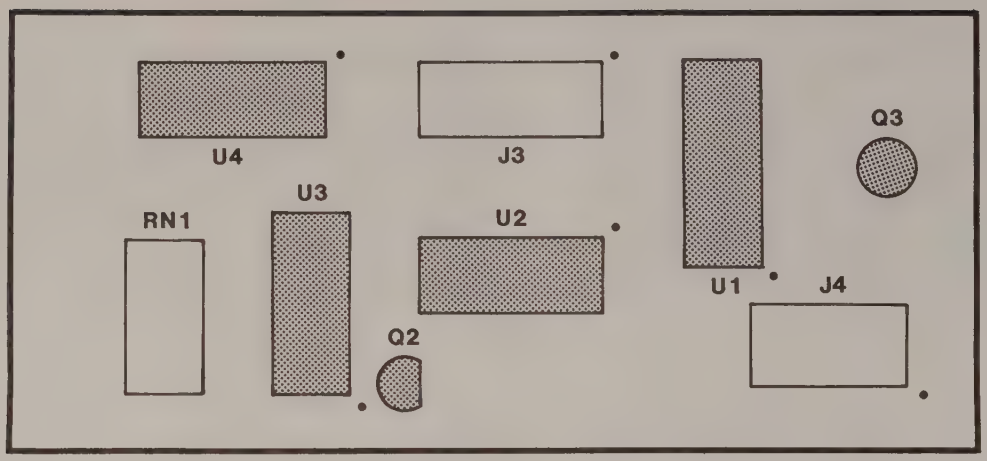


Figure 5-2. Display Drive Adjustments and Test Points

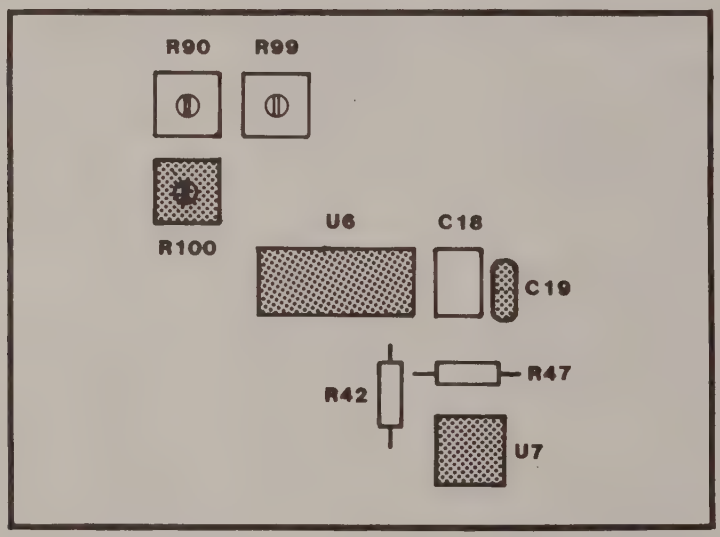


Figure 5-3. Analog/Digital Circuit Adjustments and Test Points
(Located on Main Board)

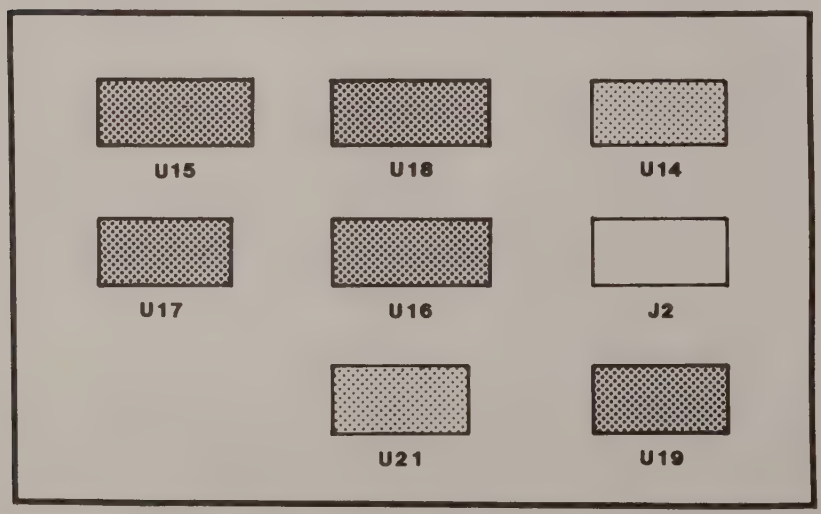


Figure 5-4. Manual and Autoranging Adjustments and Test Points
(Located on Main Board)

TABLE 5-12. DISPLAY AND DISPLAY DRIVE TROUBLESHOOTING

STEP	PROCEDURE	REQUIRED REACTION	CORRECTIVE PROCEDURE
1	Depress mA and TEST switches	All 7 segment LEDs are lit	Leave switches depressed for the following steps.
2	Measure wave shape at U1 pin 8	+ 5V - 3V 7 to 9 µs	Replace Q3, Perform Table 5-11.
3	Measure waveshape	0V to + 5V pulses	Replace U1, Proceed with Table 5-13.
4	Measure waveshape at U1 pin 3	+ 5V to - 12V pulses	Replace U1, Proceed with Table 5-13.
5	Measure waveshape at U1 pin 5	0V to + 5V pulses	Replace U1, Proceed with Table 5-15.
6	Measure digits strobes at U1 pins 2, 1, 18, 17, and 16	+5 0	Replace U1, U4.
7	Measure BCD information at U1 pins 9, 10, 11, and 12.	0 to + 5V pulses	Replace U1, U3.
8	Depress 2000 switch and mA switch.	DS-2 decimal point is lit	Replace U2, Q2.
9	Depress 200 switch and mA switch	u LED is lit	Replace DS6, Proceed with Table 5-15.
10	Depress 200 and V switches	m LED is lit	Replace DS7, Proceed with Table 5-15.

TABLE 5-13. A/D CIRCUIT TROUBLESHOOTING

STEP	PROCEDURE	REQUIRED REACTION	CORRECTIVE PROCEDURE
1	Short U6 pin 15 to input COMMON terminal.	Display reading should be 0000 ± 5	Replace U6, C19. Perform Tables 5-11 and 5-12.
2	Measure voltage at U6 pin 10.	+ 5V ± 5 mV	Replace U7.
3	Apply 1.9V dc between U6 pin 15 and input COMMON terminal.	Display reading should be 1.9000 ± 5	Replace U6, R100.

TABLE 5-14. MANUAL AND AUTORANGING CIRCUIT

STEP	FUNCTION	RANGE/ INPUT	U14-6	U21-6	U21-8	U16-11	U18-9	U18-10	U18-11	U18-12	CORRECTIVE PROCEDURE
1	V	200 mV	1	0	0	1	0	1	0	1	Replace U15, U16, U17, U18, and U19.
2	V	2 V	1	1	0	1	1	1	1	0	"
3	V	20 V	0	0	1	1	1	1	1	1	"
4	V	200 V	0	1	1	1	1	1	0	1	"
5	V	250 V	0	1	0	0	1	1	0	0	"
6	mA	200 µ	1	0	0	1	1	0	0	1	"
7	mA	2 m	1	1	0	1	1	1	1	0	"
8	mA	20 m	0	0	1	1	1	1	1	1	"
9	mA	200 m	0	1	1	1	1	1	0	1	"
10	mA	2000 m	0	1	0	0	1	1	0	0	"
11	mA	10 A	0	1	0	1	1	1	1	1	"
12	*W	200 µ	1	0	0	1	1	0	0	1	"
13	W	2 m	1	0	0	1	1	0	0	0	"
14	W	20 m	1	0	0	1	0	1	1	1	"
15	W	200 m	1	0	0	1	0	1	0	1	"
16	W	2000 m	1	0	0	1	0	1	0	0	"
17	W	10 A	1	0	0	1	1	1	1	1	"
18	dB	+ 20 dB	1	1	0	1	1	0	0	1	"

* Short input terminals, select V and wait for a steady display, select W.

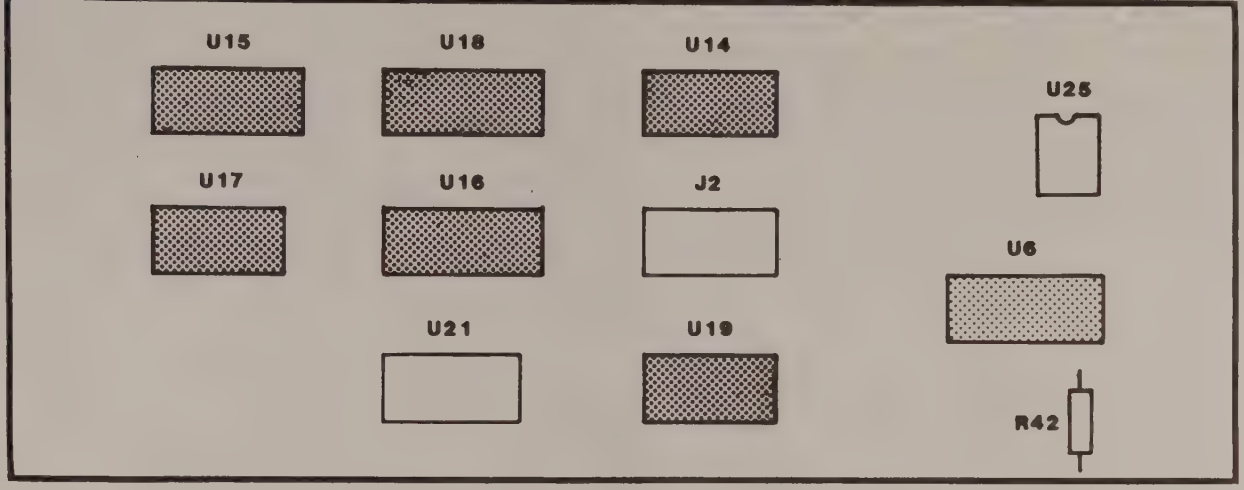


Figure 5-5. Autoranging Adjustments and Test Points (Located on Main Board)

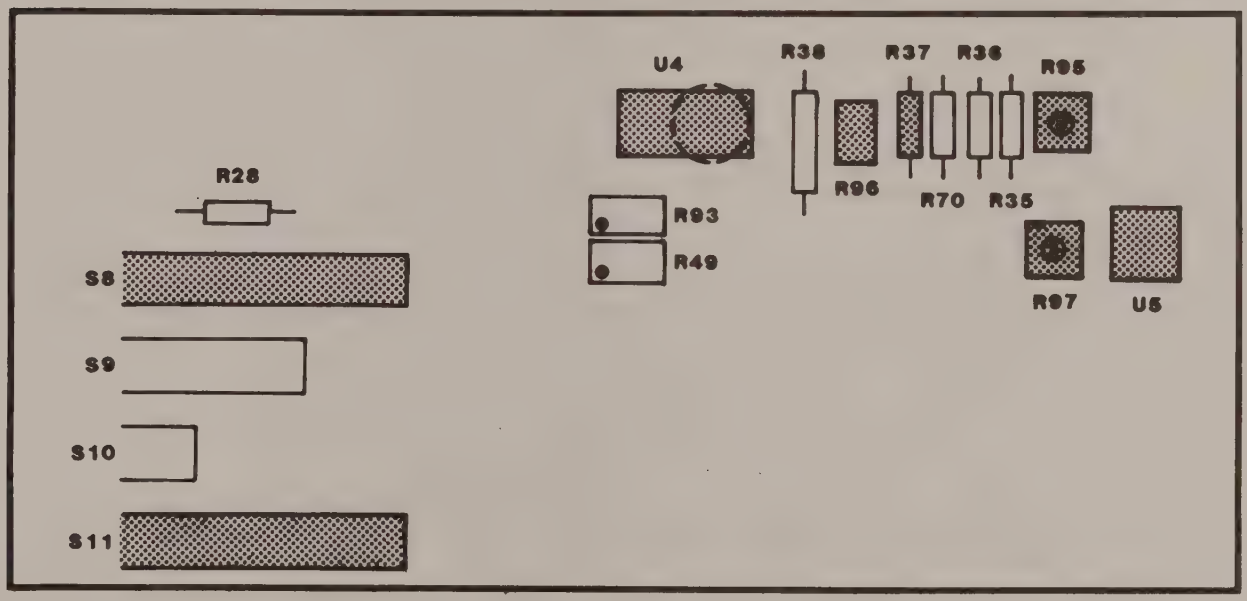


Figure 5-6. AC/DC and dB Converters Adjustments and Test Points (Located on Main Board)

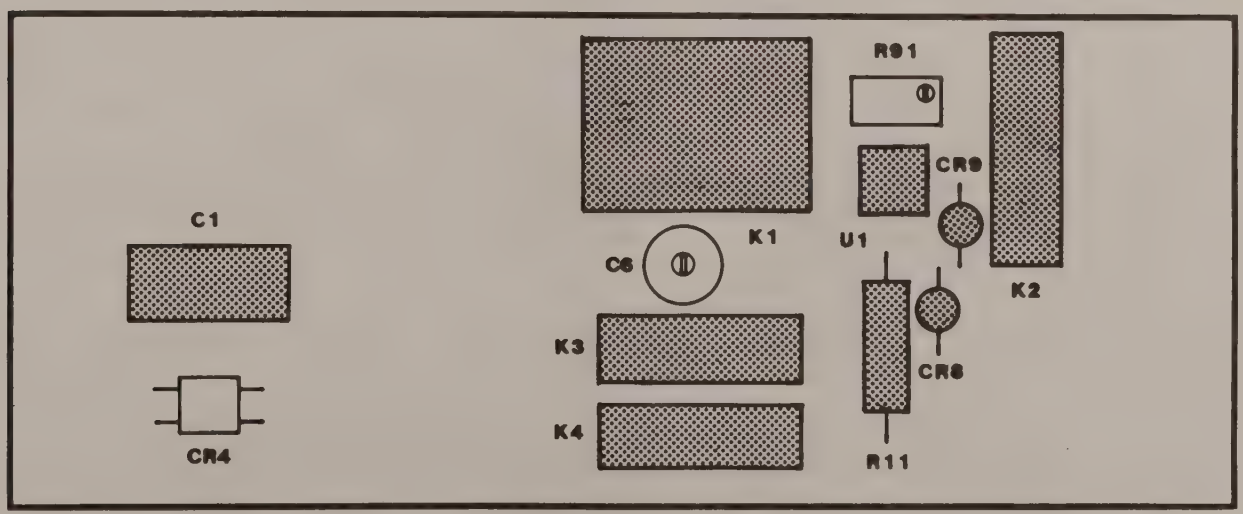


Figure 5-7. Volt Input Attenuator and Amplifier Adjustments and Test Points (Located on Main Board)

TABLE 5-15. AUTORANGING CIRCUIT

STEP	PROCEDURE	REQUIRED REACTION	CORRECTIVE PROCEDURE
1	Depress V switch. Short U6 pin 15 to input COMMON terminal. Measure signal at U14 pin 10.	1. Negative going pulses at U14 pin 10 2. m LED is illuminated	Replace U14, DS7, U15, U16, U17,U18, and U19. Perform Table 5-15.
2	Depress V switch. Apply + 2.5V dc between U6 pin 15 and input COMMON terminal. Measure signal at U14 pin 9.	1. Negative going pulses at U14 pin 9. 2. Display blinking.	Replace U14. Perform Table 5-15. Replace U15, U16, U17, U18, and U19.

TABLE 5-16. AC/DC AND dB CONVERTERS

STEP	PROCEDURE	REQUIRED REACTION	CORRECTIVE PROCEDURE
1	Select AC Couple. Short input COMMON to U4 pin 1. Depress V and 2 switches. Observe the display.	Display reading is .0000 ± 50	Perform Tables 5-11 to 5-13. Check and replace U4, R95.
2	Apply 1.9V dc between U4 pin 1 and input COMMON.	Display reading is 1.9000 ± 50	Replace U4, R96, S8C, S11F.
3	Depress dB and 20 switches. Select Ac Couple. Apply 7.75V between U4 pin 1 and input COMMON.	Display reading is + 20.00 ± 50	Replace U5, R37, R97, S8E, S8C.

TABLE 5-17. V INPUT ATTENUATOR AND AMPLIFIER

STEP	PROCEDURE	REQUIRED REACTION	CORRECTIVE PROCEDURE
1	Depress V and 2 switches. Select AC Couple. Short V and COMMON input terminals. Observe the display reading.	Display reading is .0000 ± 50	1. Perform Tables 5-11 to 5-16. 2. Replace U1. CR8, CR9, C1, R11, K1.
2	Depress V and 20 switches. Apply 19V ac between V and COMMON input terminals.	Display reading is is 19.000 ± 100	1. Perform Table 5-15. 2. Replace K3, K2.
3	Depress V and 2000 switches. Apply 100V ac between V and COMMON input terminals.	Display reading is 100.0 ± 50	1. Perform Table 5-15. 2. Replace K4.

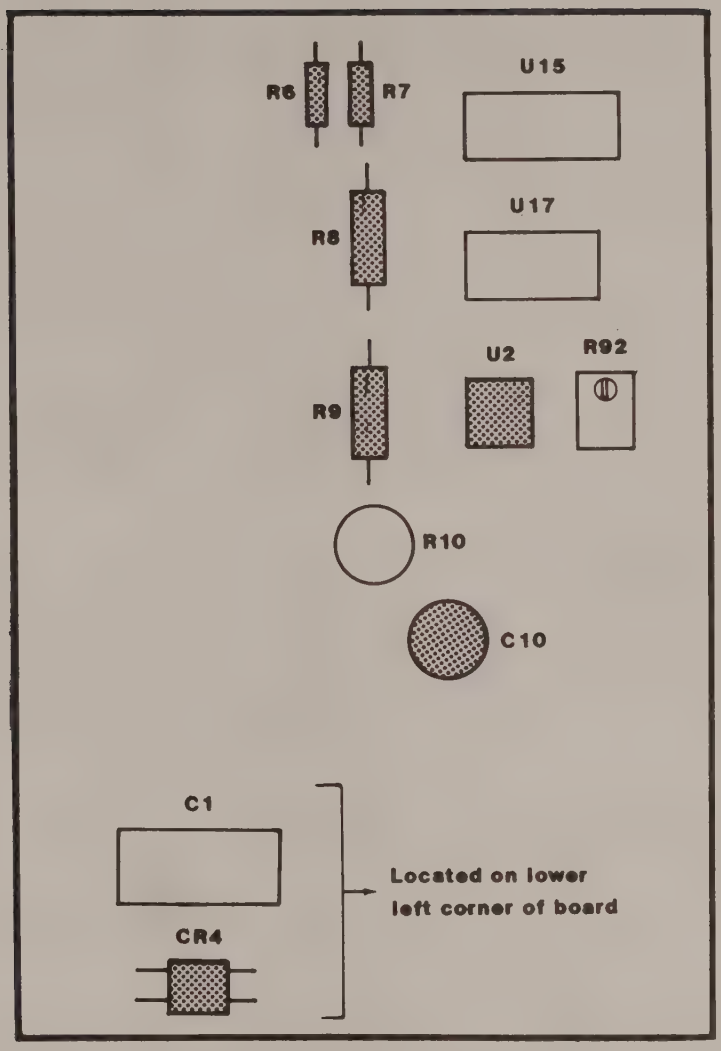


Figure 5-8. Current Shunts and Amplifier Adjustments and Test Points (Located on Main Board)

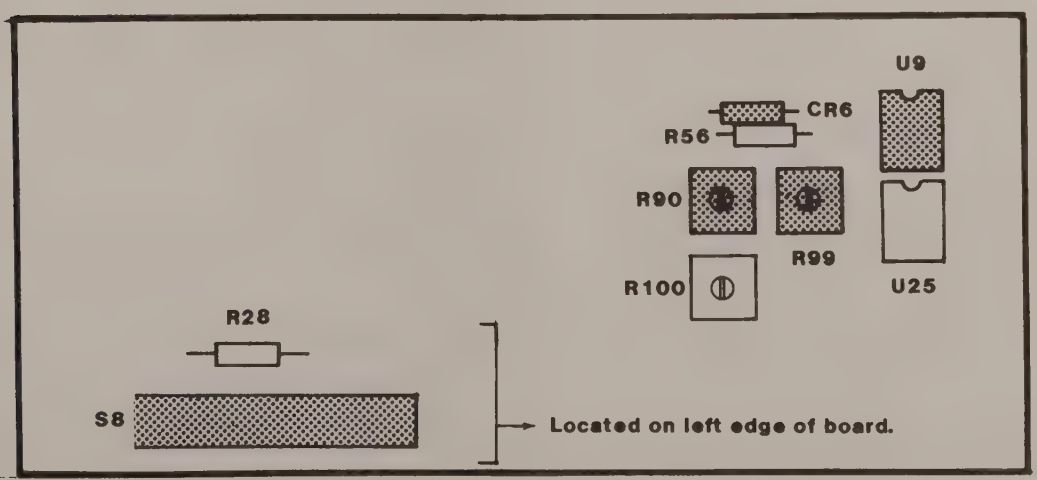


Figure 5-9. Analog Meter Adjustments and Test Points (Located on Main Board)

TABLE 5-18. CURRENT SHUNTS AND AMPLIFIER

STEP	PROCEDURE	REQUIRED REACTION	CORRECTIVE PROCEDURE
1	Depress mA and 2000 switches. Select AC Couple.	Display reading is 000.0 ± 50	1. Perform Tables 5-11 to 5-16. 2. Replace U2, C10, R6 thru R9.
2	Apply 1A ac between mA and COMMON input terminals.	Display reading is 1000.0 ± 100	1. Perform Table 5-15. 2. Replace F2, CR4.

TABLE 5-19. ANALOG METER CIRCUIT

STEP	PROCEDURE	REQUIRED REACTION	CORRECTIVE PROCEDURE
1	Depress V and 2000 switches.	Meter needle rests in the bottom position	1. Perform Tables 5-11, 5-16, and 5-17. 2. Replace M1, U9, R99, S8F.
2	Depress V and 2 switches. Select DC Couple. Apply 1V between V and COMMON input terminals.	Meter needle is approx. at mid position	1. Replace M1, R90, CR6, S8F.

TABLE 5-20. ANALOG MULTIPLIER AND COMPARATOR CIRCUITS

STEP	PROCEDURE	REQUIRED REACTION	CORRECTIVE PROCEDURE
1	Depress W and 2000 switches. Select AC Couple. Short input COMMON to U22 pin 3.	Display reading is 00.00 ± 10 m	1. Perform Tables 5-11 to 5-18. 2. Replace U22, R49.
2	Short V and COMMON input.	Display reading is 00.00 ± 10 m	Replace U3, R49, R52, R93.
3	Depress mA and 200 switches. Apply 1A ac between mA and COMMON input terminals.	1. Display reading is 00.00 ± 10 m 2. mA off limit LED is lit.	Replace U3, U13, Q3, DS10.
4	Disconnect leads from mA input. Apply 1V ac between V and COMMON input terminals.	1. Display reading is 00.00 ± 100 m 2. V OFF LIMIT LED is lit	Replace U3, U13, Q4, DS9.
5	Select DC Couple. Apply 1V ac and 1A dc to the appropriate input terminals.	Display reading is 1.000 ± 10	Replace U3.

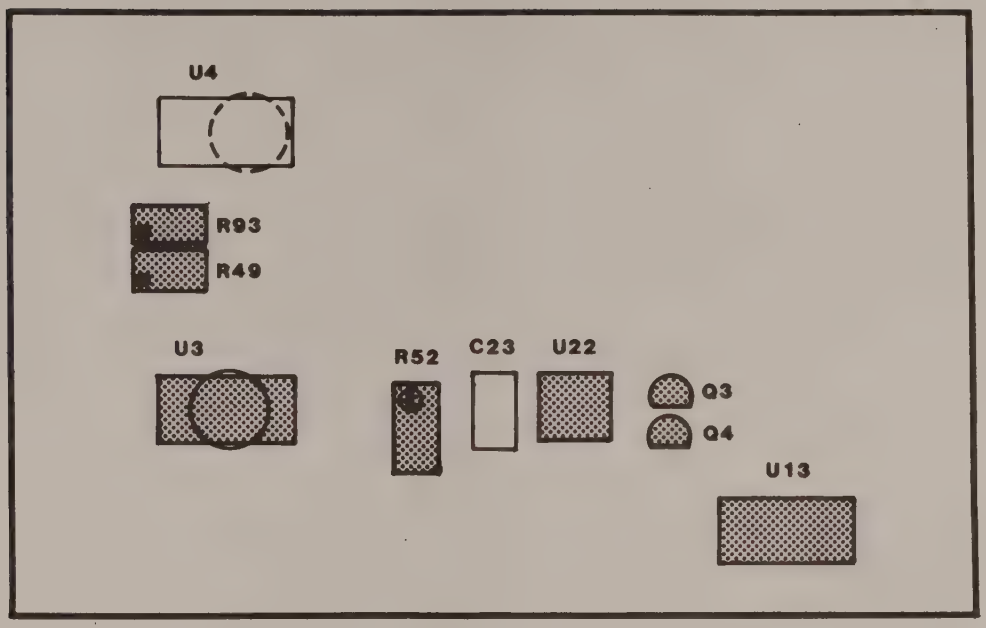


Figure 5-10. Analog Multiplier Adjustments and Test Points
(Located on Main Board)

SECTION 6

PARTS LIST & CIRCUIT DIAGRAMS

The replacement parts listed are available from the vendors listed or from Ballantine Laboratories. Your local Ballantine Field Engineering Representative may also carry a stock of parts and can assist you. If pricing quotations are required for parts and or repairs, your local representative will give the most rapid service or you may contact the Ballantine Factory directly.

When ordering replacement parts always give the following information:

a) Instrument Model number

b) Serial number

c) Ballantine Part number

d) Schematic Symbol number

e) Identification and description of part

Ballantine will do its best to improve the instrument and make changes in style of components and replacement parts. Replacement parts may differ in appearance from those found in your instrument but are always equal or superior in performance. Where necessary minor mechanical modifications may be required in the replacement of the components.

Parts are generally available locally for most replacements. The parts list calls out the recommended vendors where applicable.

Alternate components may be substituted but the use of parts specified in this parts list is recommended. A part similar to the part initially installed at the factory may be used, i.e., a 5% composition resistor may be replaced with a similar part or a 5% film resistor or the preferred 1% metal film resistor. Use of the preferred component will always simplify calibration and speed repairs.

Selected components are identified in this manual and may be replaced with a similar valued part unless re-selection is required due to replacement or change of a related part. The schematics and calibration procedures identify selected components and replacement procedures.

The Manufacturer Code is taken from Federal Supply Code Cataloging Handbooks H4-1, H4-2, and H4-3. Ballantine Code is 50423.

The following parts coding are used:

CVC	Capacitor, Variable, Ceramic
CCT	Capacitor, Ceramic, Tubular
CFP	Capacitor, Fixed, Plastic
CCD	Capacitor, Ceramic, Disc
CYF	Capacitor, Mylar, Foil
CMD	CapaciTor, Mica, Dipped
CMM	Capacitor, Mica, Molded
CEA	Capacitor, Electrolytic, Aluminum
CET	Capacitor, Electrolytic, Tantalum
DGP	Diode, General Purpose
DZG	Diode, Zener, General Purpose
DRP	Diode, Bridge, Power
FLT	Filter
ICP	Integrated Circuit
TRQ	Transistor
RFF	Resistor, Fixed, Film
RFC	Resistor, Fixed, Composition
RVC	Resistor, Variable, Composition
RFW	Resistor, Fixed, Wirewound
SWC	Switch
LMP	Lamp
TRX	Transformer

Resistors may generally be replaced by Corning Electronics (CCW) type N-55, N-60 and C-32. Allen Bradley carbon composition resistors type EB may also be used but should generally be avoided (except for emergency replacements) in favor of the preferred part listed in this parts list.

Table 6-1 lists the replaceable assemblies used in the 3501A. The parts lists for these assemblies are included in this section. Circuit diagrams of these assemblies are included in Section 7 of this manual.

TABLE 6-1. REPLACEABLE ASSEMBLIES

BALLANTINE P/N	DESCRIPTION
89-61402-1	Main Board
89-61403-1	IEEE Option (3501A-60)
89-61404-1	Display
89-61405-1	Display Driver

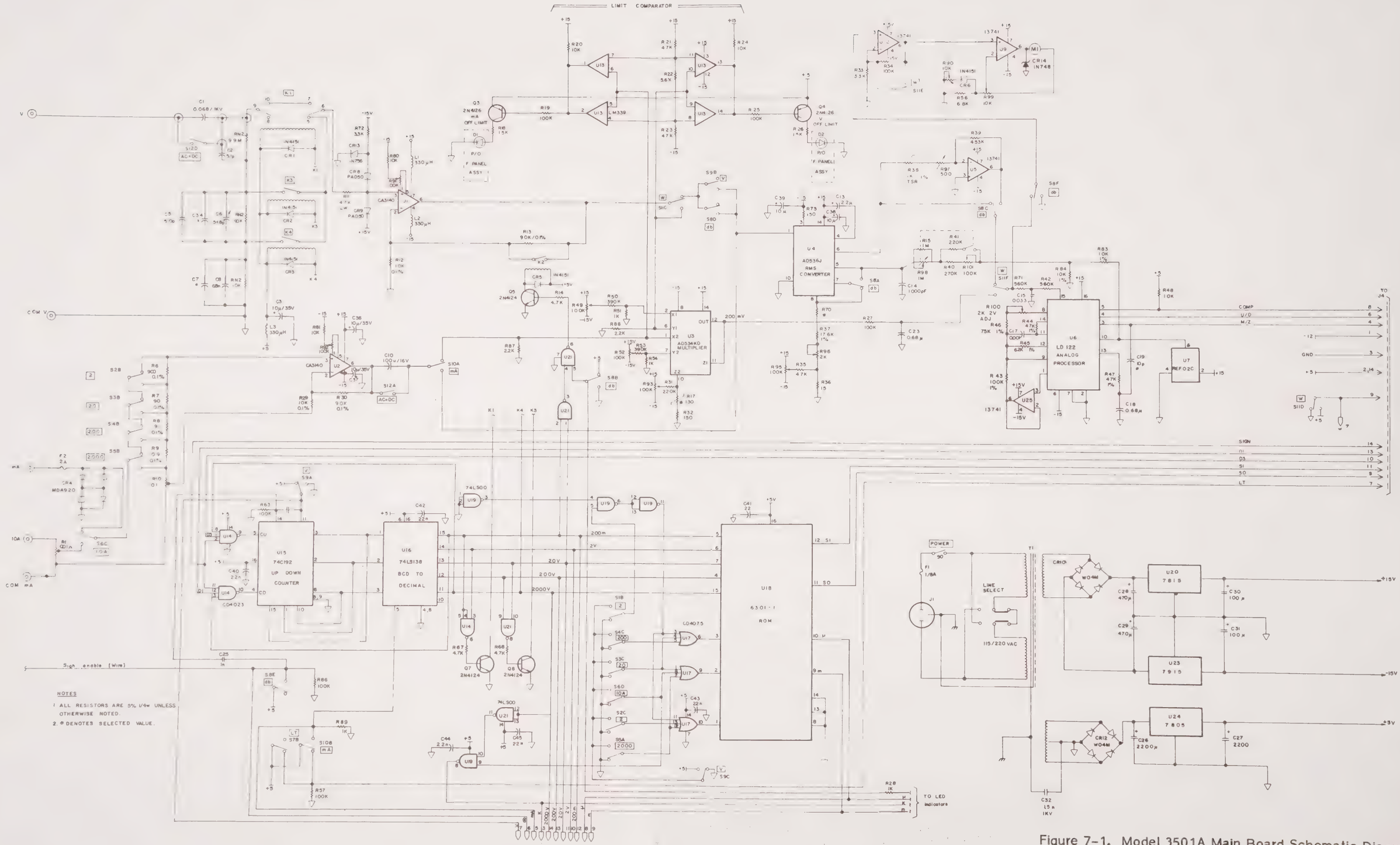


Figure 7-1. Model 3501A Main Board Schematic Diagram

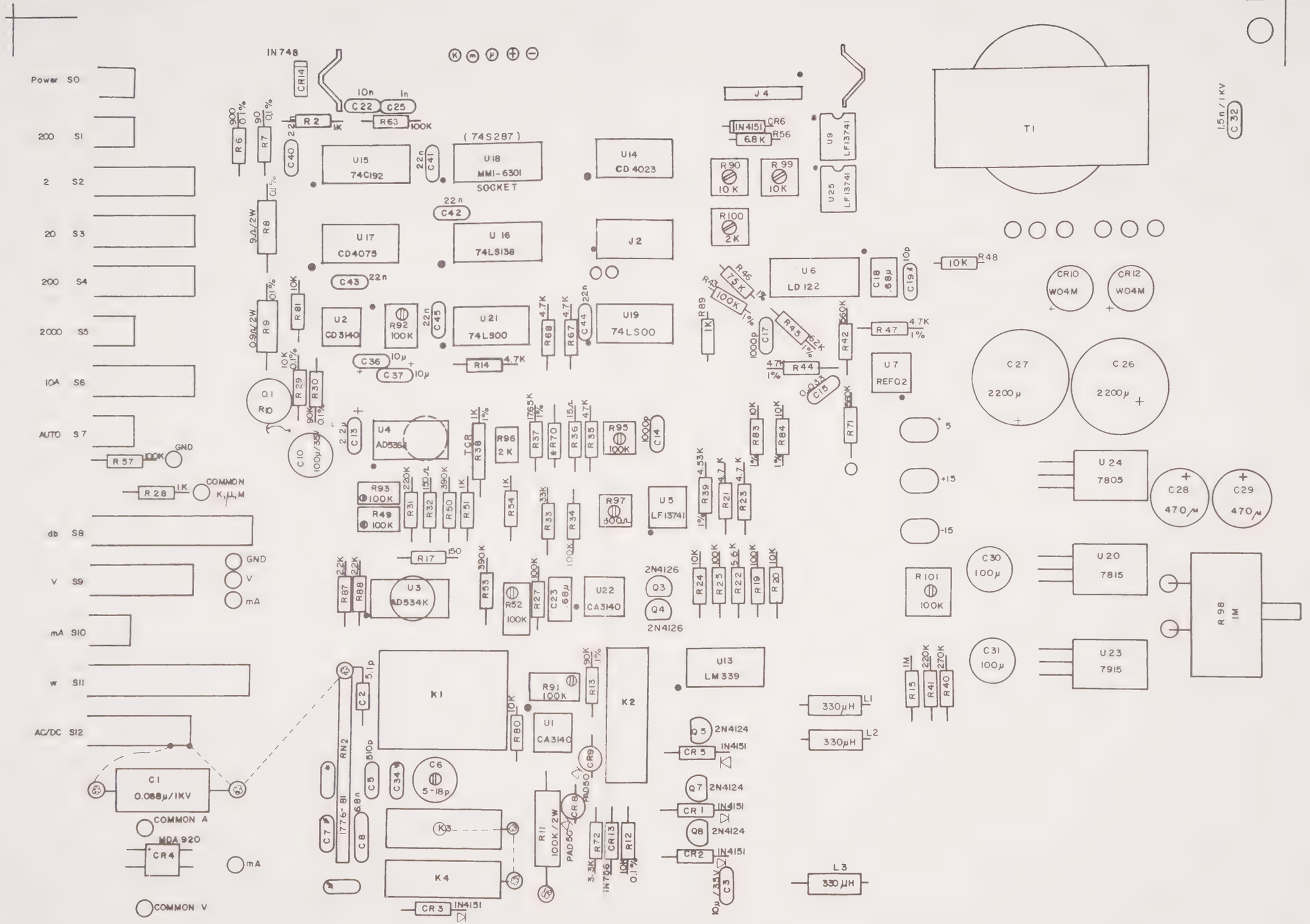


Figure 7-2. Model 3501A Main Board Component Layout

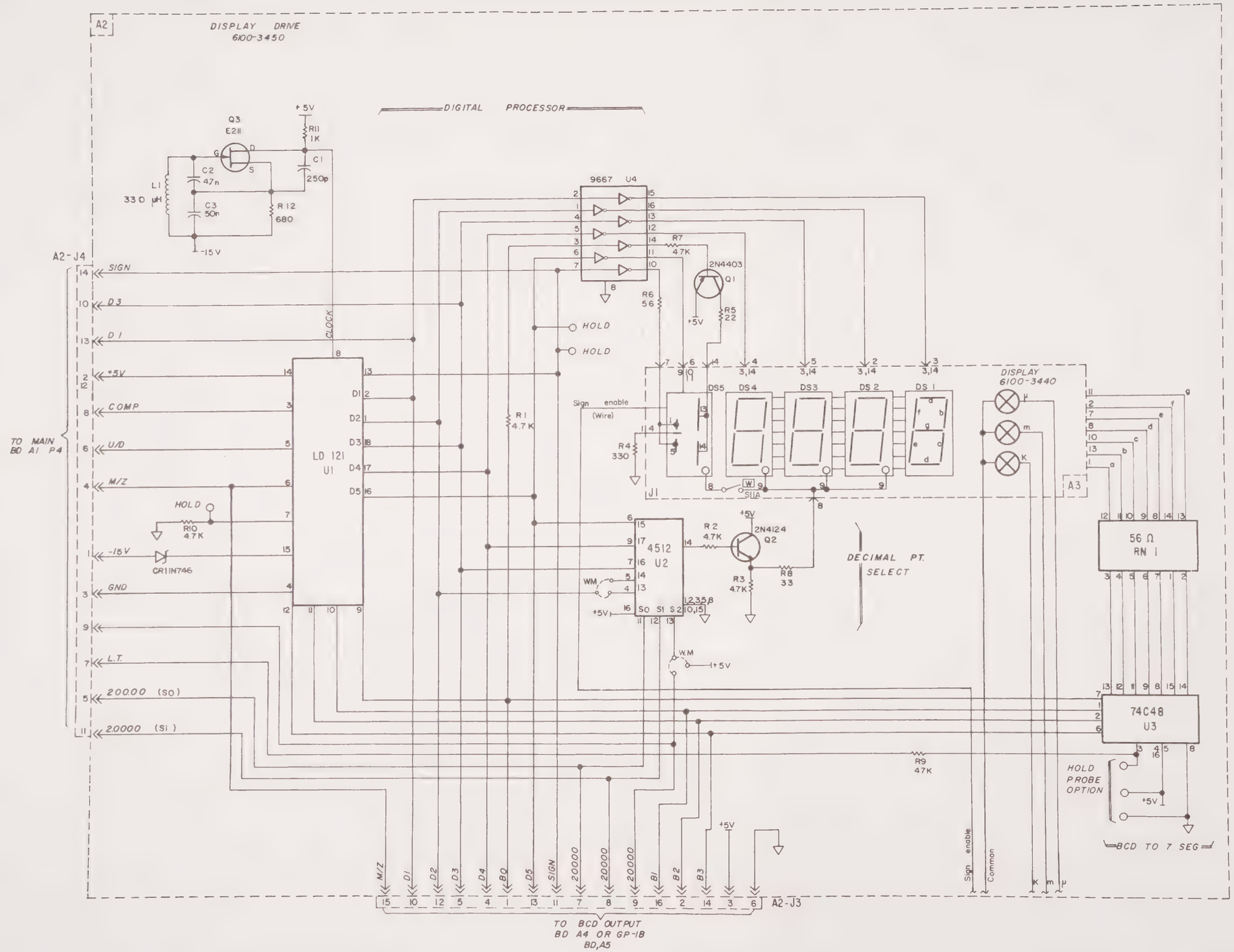
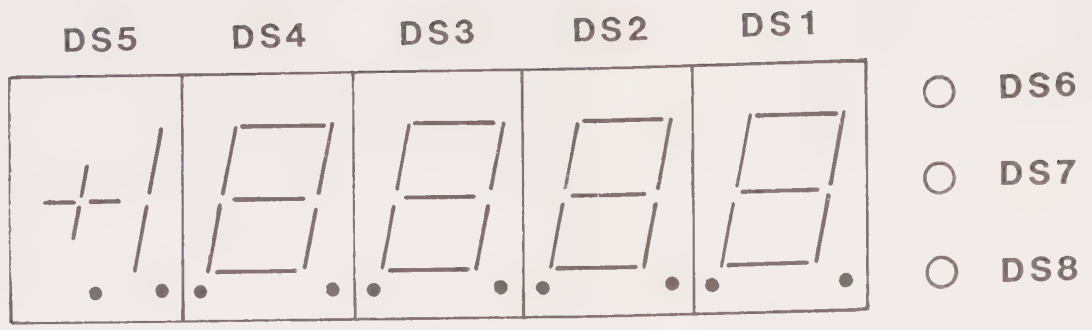


Figure 7-3. Display and Drive Schematic Diagram

Figure 7-4. Display Component Layout



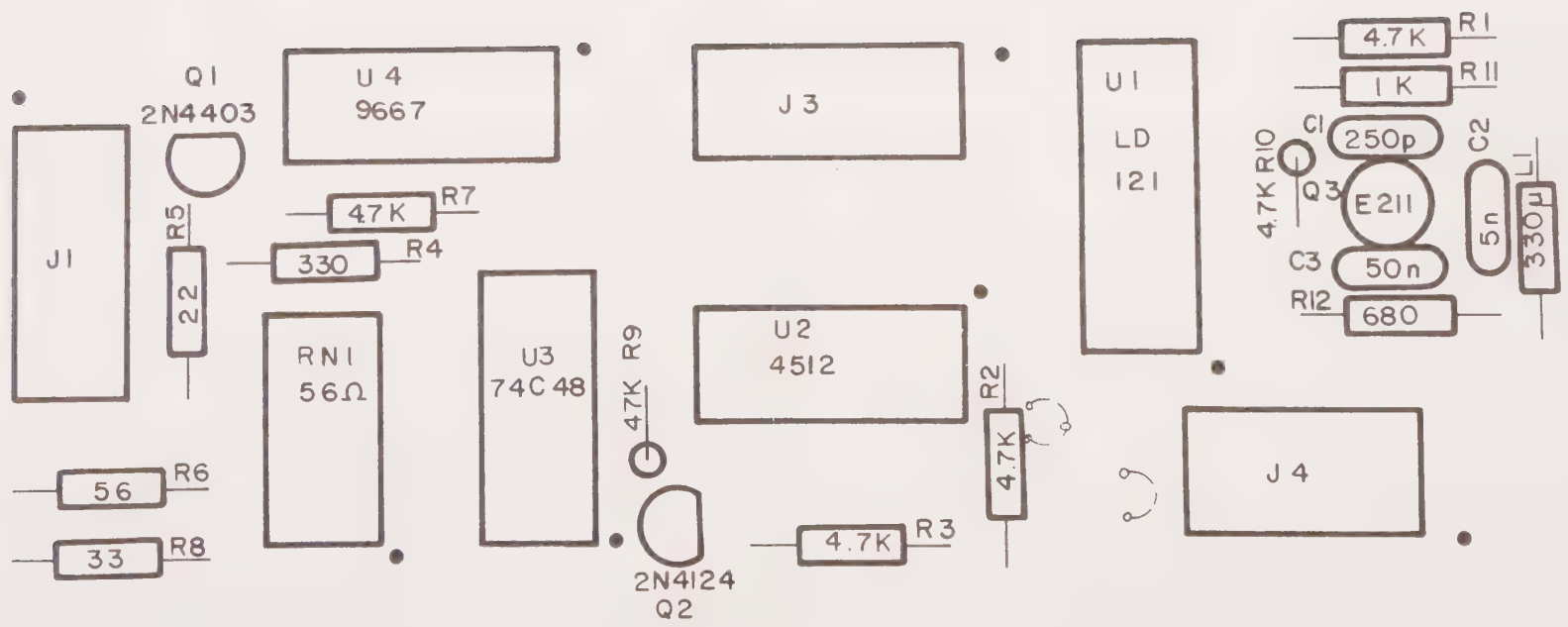


Figure 7-5. Display Drive Component Layout

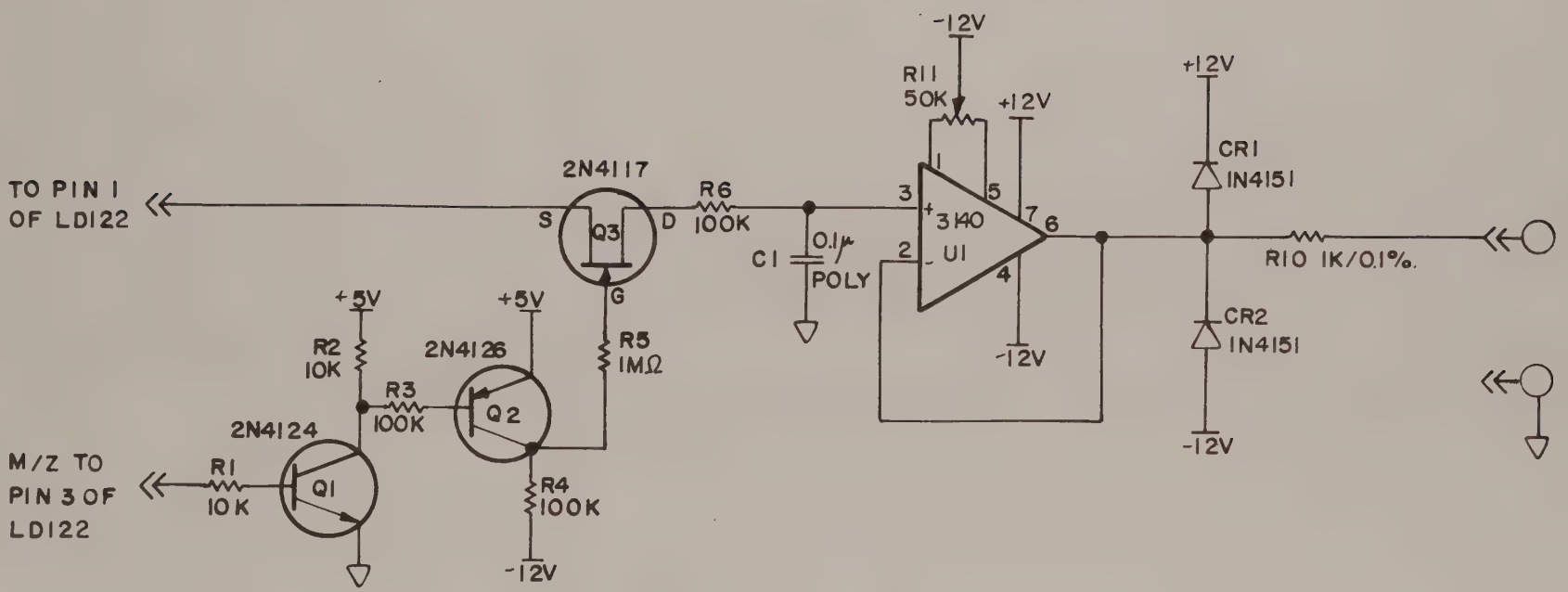


Figure 7-6. Analog Output Schematic Diagram

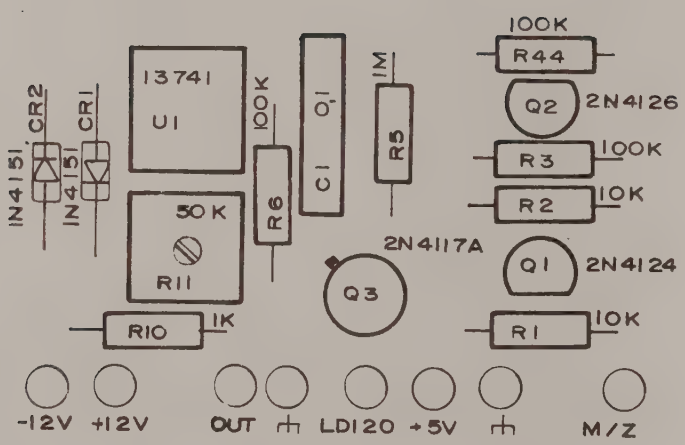


Figure 7-7. Analog Output Component Layout

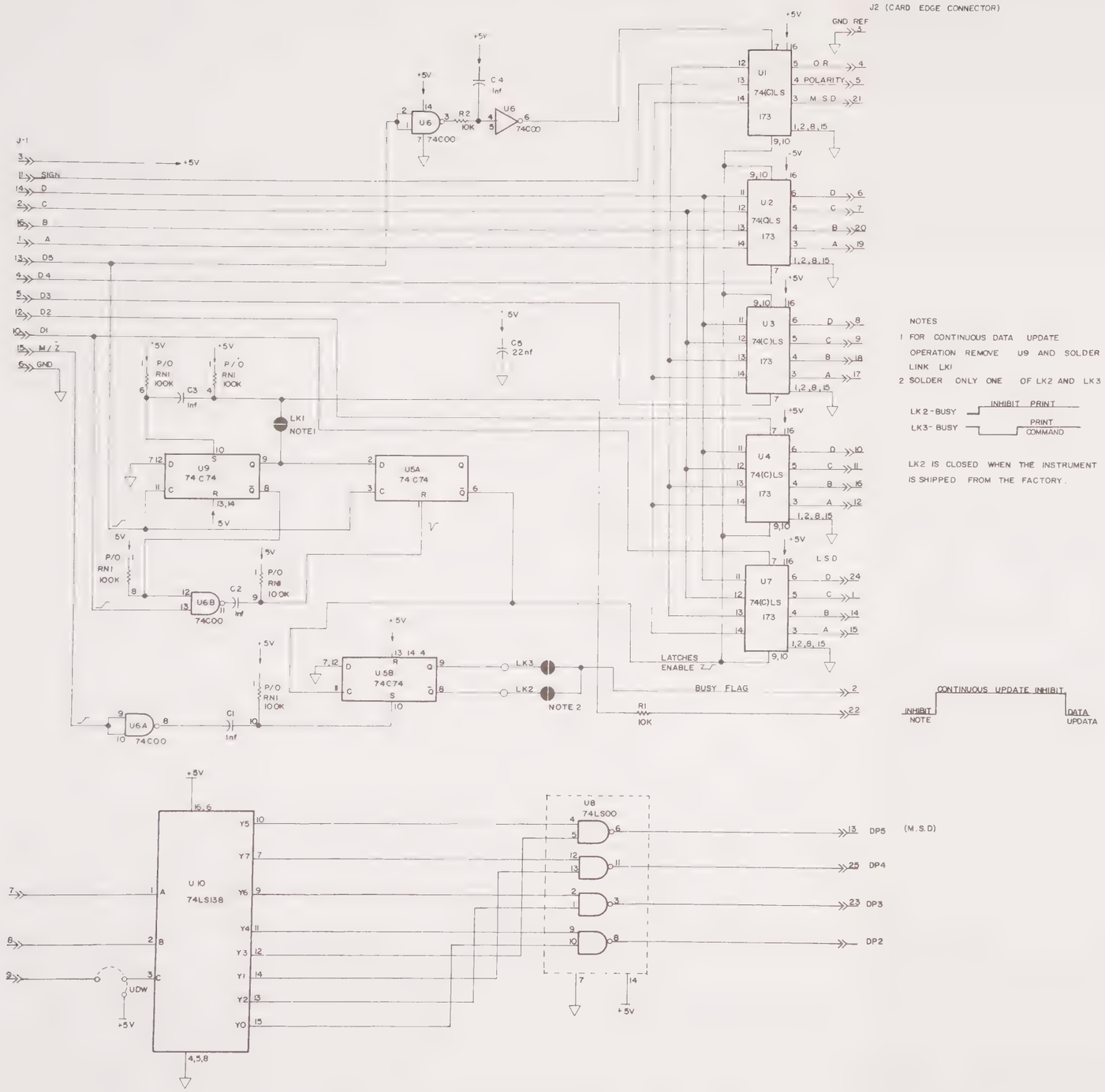


Figure 7-8. BCD Output Schematic Diagram

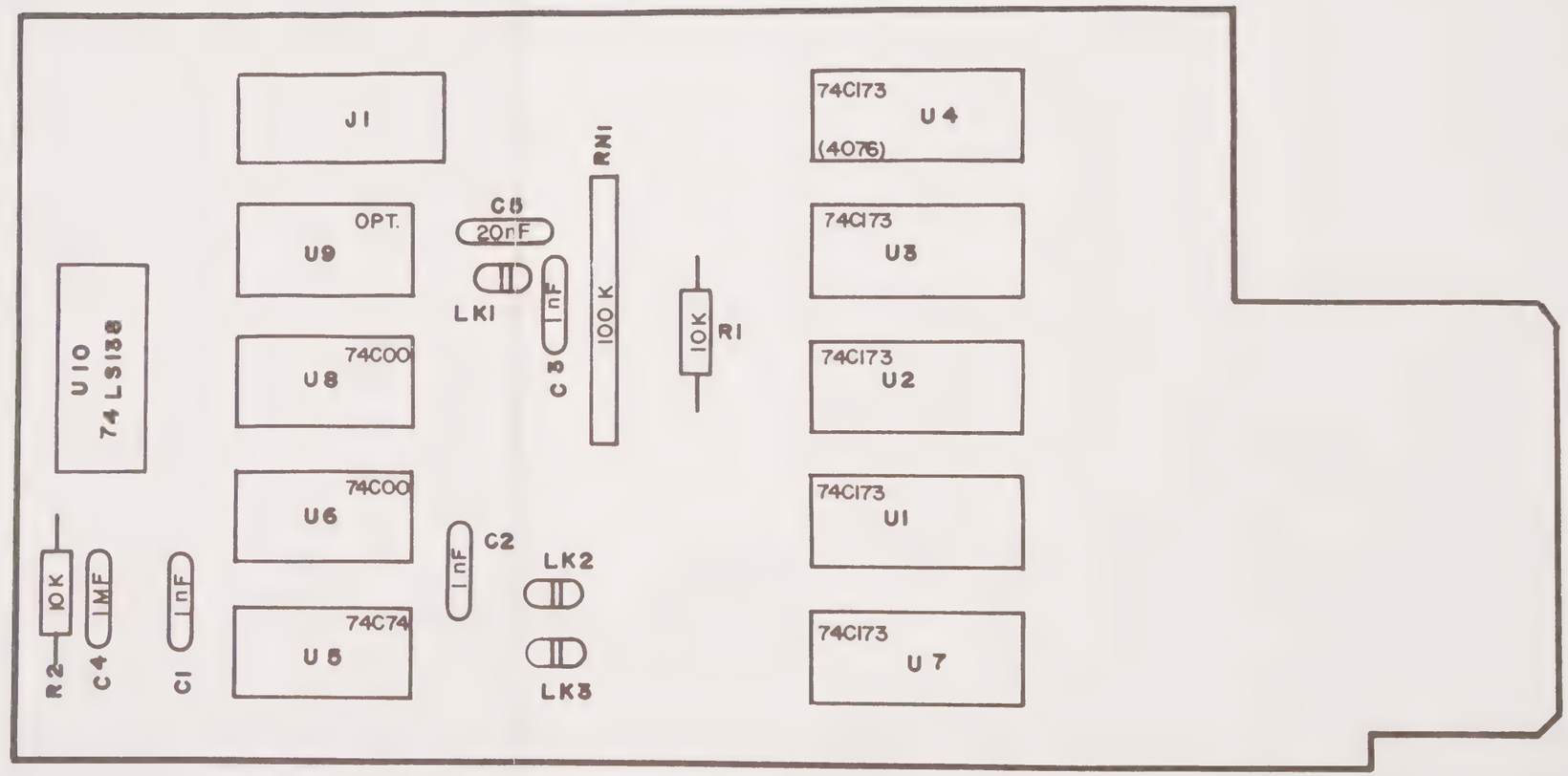


Figure 7-9. BCD Output Component Layout

SECTION 8

OPTIONS AND ACCESSORIES

8-1. INTRODUCTION

8-2. The GPIB Option provides a standard communication adapter between a controller and general purpose instrumentation. The universal GPIB Adapter complies with the IEEE Standard 488 from 1978.

8-3. SPECIFICATIONS

8-4. In accordance with IEEE-488-1978, the interface meets the interface functions specifications listed in Table 8-1.

8-5. INTERFACE SYSTEM OVERVIEW

8-6. INTERFACE SYSTEM OBJECTIVE

8-7. The overall purpose of an interface system is to provide an effective communication link over which messages are carried in an unambiguous way among a group of interconnected devices. Messages (Quantities of Information) carried by an interface system belong to either of two broad categories:

a. Messages used to manage the interface system itself, hereinafter called interface messages.

b. Messages used by the devices interconnected via the interface system that are carried by, but not used or processed by the interface system directly, hereinafter called device dependent messages.

NOTE

The detailed specification of device dependent messages is beyond the scope of this standard.

8-8. MESSAGE PATHS AND BUS STRUCTURE

8-9. The interface system contains a set of sixteen signal lines used to carry all information, interface messages and device dependent messages among interconnected devices.

8-10. Messages may be coded on one or a set of signal lines as determined by the particular message content and its relationship to the interface system.

8-11. The bus structure is organized into three sets of signal lines:

a. Data Bus, 8 signal lines

b. Data Byte Transfer Control Bus, 3 signal lines

c. General Interface Management Bus, 5 signal lines

TABLE 8-1. SPECIFICATIONS

INDENTIFICATION	INTERFACE FUNCTIONS	DESCRIPTION	STATES OMITTED
SH1	Source Handshake	Complete Capability	None
AH1	Acceptor Handshake	Complete Capability	None
T6	Talker	Basic Talker, Serial Poll, Unaddressed if [MLA]	None
LØ	No Listener		
SRØ	No Service Request		
RLØ	No Remote/Local		
PP2	Parallel Poll	Local Configuration	PUCS, PACS
DCØ	No Device Clear		
DTØ	No Device Trigger		

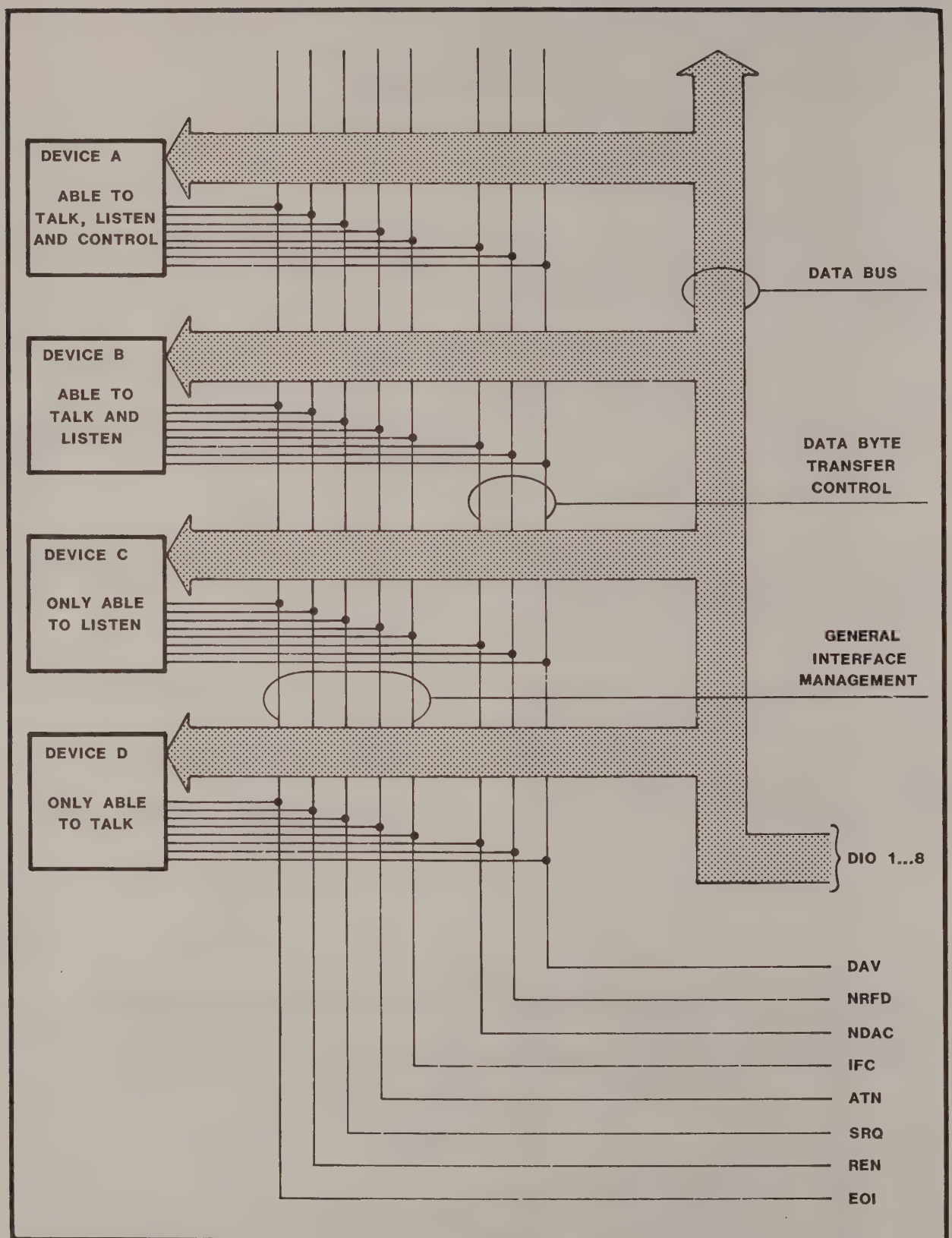


Figure 8-1. Interface Capabilities and Bus Structure

8-12. A set of eight interface signal lines carries all 7 bit interface messages and the device dependent messages:

[1] DIO1 [Data Input Output 1]
.
.
.
[8] DIO8 [Data Input Output 8]

Messages Bytes are carried on the DIO signal lines in a Bit-Parallel Byte-Serial form, asynchronously, and generally in a bidirectional manner.

NOTE

A message may be carried on an individual DIO signal line when required.

8-13. A set of three interface signal lines is used to effect the transfer of each byte of data on the DIO signal lines from an addressed talker to all addressed listeners:

a. DAV (Data Valid) is used to indicate the condition (Availability and Validity) of information on the DIO signal lines.

b. NRFD (Not Ready For Data) is used to indicate the condition of readiness of device(s) to accept data.

c. NDAC (Not Data Accepted) is used to indicate the condition of acceptance of data by device(s).

The DAV, NRFD, and NDAC signal lines operate in what is called a three-wire (interlocked) handshake process to transfer each data byte across the interface.

8-14. Five interface signal lines are used to manage an orderly flow of information across the interface:

a. ATN (Attention) is used to specify how data on the DIO signal lines are to be interpreted and which devices must respond to the data.

b. IFC (Interface Clear) is used to place the interface system, portions of which are contained in all interconnected devices, in a known quiescent state.

c. SRQ (Service Request) is used by a device to indicate the need for attention and to request an interruption of the current sequence of events.

d. REN (Remote Enable) is used (in conjunction with other messages) to select between two alternate sources of device programming data.

e. EOI (End or Identity) is used to indicate the end of a multiple byte transfer sequence or, in conjunction with ATN, to execute a polling sequence.

8-15. GPIB CONNECTOR CONTACT ASSIGNMENT

TABLE 8-2.
GPIB CONNECTOR CONTACT ASSIGNMENT

CONTACT	SIGNAL LINE	CONTACT	SIGNAL LINE
1	DIO1	13	DIO5
2	DIO2	14	DIO6
3	DIO3	15	DIO7
4	DIO4	16	DIO8
5	EOI	17	REN
6	DAV	18	GND
7	NRFD	19	GND
8	NDAC	20	GND
9	IFC	21	GND
10	SRQ	22	GND
11	ATN	23	GND
12	SHIELD	24	GND, LOGIC

8-16. FUNDAMENTAL COMMUNICATION CAPABILITIES

8-17. An effective communication link requires three basic functional elements to organize and manage the flow of information to be exchanged among devices:

a. A device acting as a listener

b. A device acting as a talker

c. A device acting as a controller

8-18. In the context of the interface system described by this standard:

a. A device with the capability to listen can be addressed by an interface message to receive device dependent messages from another device connected to the interface system.

b. A device with the capability to talk can be addressed by an interface message to send device dependent messages to another device connected to the interface system.

c. A device with the capability to control can address devices to listen or to talk. In addition, this device can send interface messages to command specified actions within other devices. A device with only this capability neither sends nor receives device dependent messages.

NOTE

The use of the word controller throughout this standard applies strictly to the management (control) of the interface system and does not imply the broad capabilities typically associated with the word in the data processing context.

8-19. ADDRESSABLE TO TALK AND ADDRESSABLE TO LISTEN MODE

8-20. The addressable to talk and addressable to listen modes are used in a system with a controller such as a calculator or computer. Each device addressable to talk or addressable to listen connected to the GPIB system must have a separate address. The talk address is user selectable by the address switch A1 through A5. Figure 8-2 shows the address switch with "Address 5" selected. The switch is binary coded (i.e., A3 has a weighting of $2^2 = 4$. A1 has a weighting of $2^0 = 1$, etc.).

NOTE

Due to the endless number of controllers on the market and the different reaction to CR and LF characters at the end of the string, the Interface gives an additional flexibility with Switch 7. This switch in position 1 will output SP, CR at the end of the string and in position 0 will output CR, LF at the end of the string. Most of the controllers will work on CR, LF position.

8-21. READING FROM THE INTERFACE

8-22. Upon completion of a measurement, the interface prepares an output string of a fixed length of 13 ASCII character code, which may be read by the controller at any time. When a controller inputs a string from the addressed to talk device, the last prepared string is sent through the bus. In a talk only mode, the string is sent through the bus as soon as the measurement has been completed.

8-23. DATA OUTPUT FORMAT

±	D	D	D	.	D	D	E	±	n		CR	LF
												CR

Measurement Data Field — Exponent

8-24. MEASUREMENT DATA FIELD

8-25. The data field consists of a 6 character string. The string begins with the sign + or - followed by the digits in descending order of significance. The decimal point may appear in any of the positions 2, 3, 4, 5, or 6 in the string. Leading zeros have not been suppressed.

8-26. EXPONENT

8-27. Preceded by an "E" and the sign + or - the exponent will be a multiple of 3. The string is in engineering format. The unit may be volt, amp, or watt for the Model 3501A.

8-28. OVERRANGE INDICATION

O	V	E	R	R	A	N	G	E	␣	␣	CR	LF
											␣	CR

8-29. SERIAL POLL

8-30. The status byte message is output by the interface in response to a Serial Poll. The response will always be 0.

8-31. PARALLEL POLL

8-32. The universal interface implements the protocol for Parallel Poll 2 (PP 2). Whenever the device senses both EOI and ATN true, it will automatically send its status bit on an assigned data line. (This line is binary equivalent to the three last significant address bits of the device.) This status bit will show the devices needed for service which is generated in the same conditions as for SRQ (Always 0).

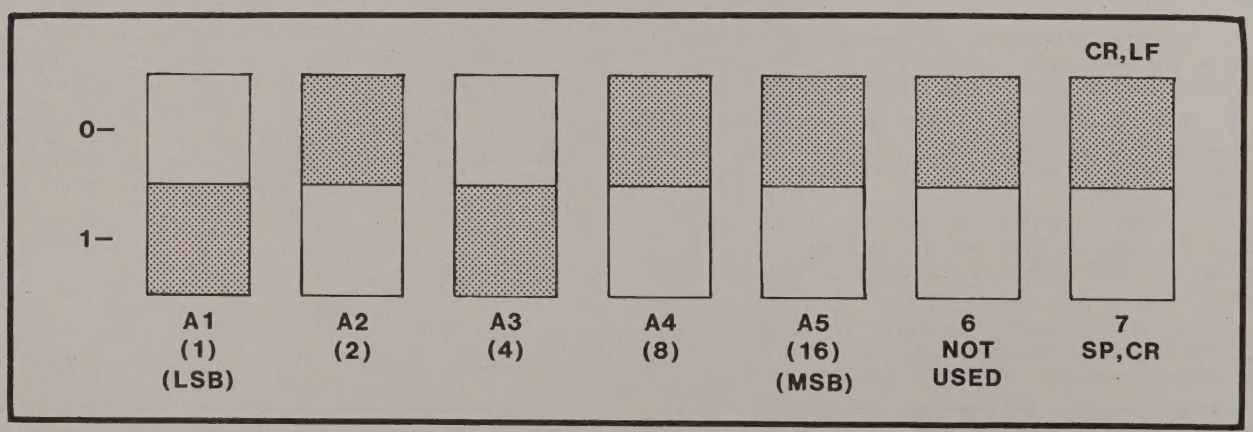


Figure 8-2. Address Switch

MP MASTER
MA31985

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